The Mining Magazine

VOL. 102. No. 6. LONDON. PRICE: 3s.; With postage 3s. 8d.

The Mining Magazine

PUBLISHED on the 15th of each month at SALISBURY HOUSE, LONDON, E.C. 2
for MINING PUBLICATIONS, LTD.

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PRICE 3s. ; with postage 3s. 8d. Annual subscription, including postage, 35s. ; U.S.A., $6.00.

Vol. 102. LONDON, JUNE, 1960. No. 6.

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EDITORIAL

AT the end of May the 1960 issue of Skinner's "Mining Year Book" made its welcome appearance. This valuable reference work, now in its 74th consecutive year, contains particulars of some 1,000 mining and metal companies operating in all parts of the world. In addition to the usual tables and the "Buyers' Guide" section there is a useful list of mining engineers and managers indicating the companies in the book with which they are connected.

IN its annual report for 1959, recently issued, the British Non-Ferrous Metals Research Association refers appreciatively to the facilities now available in the laboratory block opened a year ago by Sir Alexander Fleck. This has enabled the Association to make greater progress with the work it has in hand, much of it concerned with works processes and process control. Within this group of "end use" investigations, the report says, the larger proportion was concerned directly or indirectly with improvements in corrosion resistance, either of a particular metal or alloy used unprotected or of non-ferrous metals applied as protective coatings. In regard to control co-operative studies of rapid methods of chemical analysis, previously mainly concerned with methods applicable to copper alloys, were extended during the year to include electroplating solutions. The main development, however, in analytical techniques is, it is emphasized, in X-ray fluorescence analysis. During the year considerable progress was made in the development of procedures for obviating certain inter-element effects which could lead to spurious results. In parallel with research on these lines on the Association's own equipment examination and testing of the performance of an automatic direct-recording industrial unit has continued and, as a result of information provided by the Association, supplementing demonstrations of the technique, several members have decided to adopt this method of analysis and two have already installed these intially expensive but time and labour-saving units for routine control work. Also referred to is electron probe micro-analysis, although this is a research technique rather than a process control tool. For some years the Association, together with the other metallurgical research associations, has helped to finance development work at Associated Electrical Industries, Ltd., laboratories on the Castaing technique by which it is possible to select a particle under the microscope and analyse it. The prototype of the A.E.I. commercial instrument was lent to the Association for a short time and its utility demonstrated in principle on a few members' problems, although the equipment at that time was not in its final form. It is possible with this instrument to obtain an analysis of particles that are only one micron in diameter, whether they be true parts of the structure or adventitious inclusions.

EARLY in May the Cornish Mining Development Association held its annual meeting in Camborne. The Association has been in existence for some 12 years, but it now feels that its efforts to promote an interest in a revival of metalliferous mining in Great Britain have been largely defeated by what is described as the "entirely negative attitude" of the Government. Those interested in the mineral potential of these islands must frequently have shared the sense of frustration felt by the Association and would agree, no doubt, that "a great deal has happened since the end of the last war to emphasize this country's need of an active mineral policy" and that "successive governments have neglected this very important matter." The Association, therefore, at the meeting referred to decided to give the widest publicity to its report by issuing it as a pamphlet, which is now available.[1]

Our reviewer, dealing with the volume containing the proceedings of the Symposium arranged by the Institution of Mining and Metallurgy in collaboration with the United Kingdom Metal Mining Association in the February issue, could only express in other words a sense of frustration equal to that of the Cornish Association. It will be recalled that the main purpose of the I.M.M. Symposium was "to prepare a foundation of fact and opinion on which to build a new approach to the Government for assistance," earlier attempts having been unsuccessful in arousing any interest in revival on the part of the authorities. The Cornish Association is resolved then, to try again, and it can only be hoped it has better success. In its

[1] "Metals for Britain." Par, Cornwall: The Cornish Mining Development Association.

memorandum, for such it can be described, it calls attention to the urgent need for Britain to start to evaluate the mineral reserves which still exist in these islands and to enunciate a mineral policy which will encourage the base-metal mining industry. It is felt that the most important action that the Government can take is to modify its fiscal policy in regard to taxation of mining ventures and realize the urgent need for further geological and technical research. Another need the Association believes is that public interest should be aroused by adequate and persistent publicity. It can be repeated—others have failed, may this Cornish memorandum touch off a degree of public response.

The Future for Mining Geologists

For his address to the Institution of Mining and Metallurgy last month, following his induction to the Chair, the new president, Professor David Williams, elected to review "Progress in Mining Geology: Training, Research, and Employment." Dr. Williams holds the view that geologists have for long kept their light too much under the bushel. As a consequence, he feels that "compared with other sciences which have been glamorized in the Press and elsewhere geology has done little to advertise its cultural and practical usefulness, or to emphasize its intimate concern with the ultimate source of man's wealth and industrial prosperity. Lack of official appreciation of geology," he goes on to say, "is glaringly exemplified by the fact that even as late as 1938–39 there were only about 50 geologists engaged on all the Colonial Geological Surveys, spread out over an aggregate area of millions of square miles. Although these Surveys have accomplished admirable work in difficult circumstances, their achievements would obviously have been much greater and their mineral discoveries more numerous had they been adequately staffed and included more specialists in mineral exploration." The president then went on to emphasize "the spectacular success of mineral exploration in the U.S.S.R. since the revolution" and to emphasize the practical results that have emerged out of educational policies that are so different from our own. While at present there is, Dr. Williams suggests, small sign of mineral shortages in the western world, there is still "a vital need to develop better techniques of mineral exploration designed to disclose hidden deposits," so much less easy to find than the outcrops which have so far sufficed to supply the needs of mankind. To this end, the president suggested, "more and better-qualified mining geologists are needed" and his address therefore was directed to a review of training, research, and employment.

Professor Williams thus went on to review present undergraduate training at the Imperial College of Science and Technology, where there has been evolved a course which supplies an admirable blend of theoretical instruction and practical work. He is sure, however, that the fundamental training in "pure" geology should be supplemented by postgraduate work in mineral exploration. To this end, therefore, he is of the opinion that much help could be provided at this point by the mining industry itself. More postgraduate bursaries of the type already sponsored by certain mining houses should be forthcoming, while, in addition, Dr. Williams suggests the industry might also help itself by tendering advice and guidance in the conduct of these courses at appropriate centres, by contributing funds towards their proper establishment and operation, and by providing means for those in charge of undergraduate and postgraduate training to replenish their knowledge by visiting overseas mining fields and research organizations. Certainly a training of this breadth should go a long way to providing those highly-trained types that are so much in demand. All that remains is to be sure that they get the employment they best fulfill.

The question of employment is the last facet of his thesis to be examined by Professor Williams, who recognizes the "cyclic weakness of geological employment in the mining industry, due to recurrent 'booms' and 'recessions'"—a serious matter not only for the geologist but also for the profession and the industry. "Some geologists succumb to the uncertainty of employment by forsaking their chosen career, the fear of impecuniosity being more compelling than dedication to the science." Dr. Williams closed his address by asking whether "are we in the British Commonwealth right in not making more practical use of geology" or are "the Russians wrong in having a Ministry of Geology and scores of thousands of geologists?" To him, apparently, the answer is obvious, but we have the feeling that it would not be ours. It is surely, a matter of proportion; more geologists, more

trained geologists, particularly those able in mineral exploration, are certainly needed—but not more than we, or the Government, can possibly employ.

Geological Work and the D.S.I.R.

The report of the Council for Scientific and Industrial Research,[1] issued last month, emphasizes the steady expansion of the Department's work in accordance with the second five-year plan, a trend particularly marked in aid for special researches and post-graduate training at universities and colleges of technology. It also draws attention to changes made during previous years in the functions and organization of some of the Department's research stations and to the co-operation which exists between the various research organizations.

In the year under review the Department increased the number of grants to universities and technical colleges in every field except mathematics. In connexion with geology attention is drawn to a grant of £1,500 made to Durham University for sea-borne geophysical work off the north-east coast of England in extension of land surveys in Durham and Northumberland. This survey, which is being carried out by Dr. M. H. P. Bott, includes an attempt to find out more about the eastern margin of the coalfield. Another grant of £3,550 for underwater geological research was awarded to Bristol University, where Professor W. F. Whittard is directing the investigation on the submarine geology of the continental shelf of the Western Approaches, English Channel, between latitudes 48½° and 50½°, leading down the Continental slope to depths of just under 3,000 fathoms. A geological map of the sea-bed is to be prepared and the research techniques will include underwater photography, including television-camera scanning to depths of about 3,000 ft.

Since the report appeared there has been the announcement of a special grant. This is of £36,050 and it has been awarded by the Department to Durham University to sink a bore-hole at Rookhope, Co. Durham, to investigate the deep structure of the Pennines. The investigation will be led by Professor K. C. Dunham and should help those genetic studies of the mineralization of the Northern Pennines which have led to the theory that granite is intruded into the foundation rocks. A recent geophysical survey by Dr. M. H. P. Bott and Dr. D. Masson-Smith has revealed a large steep-sided negative anomaly, which suggests that the depth of the granitic stock is 3,000 ft. with a suggested maximum of 5,000 ft. In addition the boring operation will produce valuable information on the Carboniferous and Lower Palaeozoic stratigraphical succession and it may facilitate future exploration for useful minerals.

[1] "The Report of the Research Council of the Department of Scientific and Industrial Research." (Cmnd 1049.) London: H.M. Stationery Office. Price 4s. 6d., by post 4s. 10d.

Camborne School of Mines

The annual dinner of the Camborne School of Metalliferous Mining took place on May 20 last, some 200 students past and present, with their guests, gathering together to provide the usual cheerful evening's entertainment. The toast of the School was on this occasion proposed by Mr. W. G. Bennett, of Maxam Power, Ltd. (one of the Holman Group of companies), who drew attention to the wide range of countries from which students at the School are drawn. In response, Mr. R. A. Gorges, the new principal, had much to say regarding the future of the School, about which there is at present a degree of uncertainty. Apparently the Minister of Education holds the view that "the School should move towards Redruth"—probably, that is, away from Fore Street and into the area of the Cornwall Technical College. Mr. Gorges suggested that any such move would be detrimental, since the demand for graduates from Camborne was as great as ever. The School, he thought, was at a cross-roads. There was urgent need of modernization, yet no one at Camborne viewed the possibility of a move to Redruth with any degree of pleasure. At the same time if plans were made to join the university at either Exeter or Bristol there might be a greater danger of the School's losing its identity. However, said Mr. Gorges, the School's governors were in close touch with industry and it was to be hoped that the Minister would be persuaded to think of them on university rather than technical college lines.

The toast of the Institution of Mining and Metallurgy was proposed by Mr. A. C. Owen, Chairman of the Governors, the response being made by Professor David Williams, the Institution's new president.

MONTHLY REVIEW

Introduction.—The breakdown in the "Summit" talks and uncertainties as to the future of European trade arrangements have naturally tended to depress business confidence. In spite of this industrial activity continues at a high level and commodity prices remain comparatively steady.

Transvaal.—On May 18 it was announced by WESTERN DEEP LEVELS that the Ventersdorp Contact Reef had been intersected in the No. 2 ventilation shaft at a depth of 5,549 ft. below collar, dipping in a south-easterly direction at 25°. The Reef was sampled at intervals of 5 ft. around the perimeter of the shaft, the sections sampled giving average values of 10·24 dwt. a ton over a channel width of 48·36 in.

Another reef intersection was later reported by VAAL REEFS EXPLORATION AND MINING where the Vaal Reef has been cut in the No. 2 ventilation shaft at 4,905 ft. below collar, dipping in a south-easterly direction at 7°. The reef was sampled around the shaft, the sections sampled giving average values of 33·15 dwt. a ton for gold and 0·72 lb. a ton for uranium over a channel width of 14·27 in. At the annual meeting of the company held in Johannesburg last month shareholders were informed that at the mine the main shaft of No. 2 shaft system is now down to 6,106 ft., and a station is being cut on 62 level. The ventilation shaft has reached a depth of 4,682 ft. of its final planned depth of 7,200 ft. The footage sampled in the vicinity of No. 2 shaft in the middle of May was 2,825 ft. assaying 596 in.-dwt. (gold) and 40·07 in.-lb. (uranium); payability was 82·8%.

The operations of STILFONTEIN GOLD MINING in 1959 resulted in a profit of £6,046,190, the accounts showing £6,632,013 available, of which dividends totalling 3s. 6d. a share required £2,286,011. In the year 1,754,000 tons of ore was milled and 830,892 oz. of gold recovered, while the output of the uranium plant was 352,985 lb. of oxide. Ore reserves are given as 5,265,000 tons averaging 9·45 dwt. in gold and 0·323 lb. of uranium per ton.

The report of CONSOLIDATED MURCHISON (TRANSVAAL) GOLDFIELDS for 1959 shows a profit of £354,356 and £879,218 available, of which dividends equal to 165% require £343,000. The 149,328 tons of ore crushed in the year yielded 2,383 oz. of gold and 22,155 short tons of antimonial concentrates and cobbed ore.

WEST RAND INVESTMENT TRUST reports a profit of £2,250,856 for 1959, the accounts showing £2,559,811 available, of which dividends amounting to 3s. 6d. a share absorbed £1,822,929.

The accounts of EAST RAND CONSOLIDATED for 1959 show a profit of £79,893 and a total of £95,313 available, of which a 10% dividend requires £36,750.

Orange Free State.—The report of VIRGINIA ORANGE FREE STATE GOLD MINING for 1959 shows a total of £1,932,802 available for appropriation, most of it required for expenditure on fixed assets and the repayment of loans. In the year 1,546,000 tons of ore was treated, 367,356 oz. of gold and 649,736 lb. of uranium oxide being recovered.

The MERRIESPRUIT report for last year states that the directors are considering the possibility of some arrangement whereby Virginia mine would treat ore on a royalty basis. Development has been confined mainly to exploratory work on Basal Reef in the area where underground boreholes had indicated payable reef. Of 2,020 ft. sampled during 1959, 65·6% proved payable at an average value of 304 in.-dwt. and 15·39 in.-lb. over a channel width of 32·7 in. The Virginia 28th level haulage was continued towards No. 1 shaft and on March 31 the haulage and its companion had advanced to 7,988 ft. and 8,000 ft., respectively, inside the Merriespruit property.

The ORANGE FREE STATE INVESTMENT TRUST reports a profit of £2,655,173 for 1959, the accounts showing £2,940,080 available. Of this amount dividends equal to 4s. 9d. a share require £2,599,059.

Diamonds.—Speaking at the annual meeting of DE BEERS CONSOLIDATED MINES held earlier this month in Johannesburg, the chairman, Mr. H. F. Oppenheimer, said that, as mentioned in the report, diamond sales in 1959 reached the record total of £91,135,943—over £14,000,000 higher than in any previous year. He went on to say that the market for diamonds in the current year continues to be very satisfactory. For the first five months the gem trade totalled £25,363,090, as compared with £25,517,460 for the same period last year, and industrial diamond sales

amounted to £10,068,189, compared with £12,241,262 for the first five months of 1959.

During 1959 the deepening of No. 1 vertical shaft at PREMIER (TRANSVAAL) DIAMOND MINING was completed at 1,902 ft. and good progress made with development in connexion with the " drop down " to the 1,570-ft. level. Tunnelling during the year under review amounted to 34,585 ft., of which 22,865 ft. were in blue ground and 11,720 ft. in rock. A new electric winder has been installed at No. 2 shaft. The treatment plant operated satisfactorily during the year, treating an average of 444,122 loads per month, but a secondary H.M.S. unit is being installed to retreat the H.M.S. concentrates in order to improve recovery and reduce the tonnage of concentrates handled in the recovery plant. In the year under review 5,429,360 loads of ground were treated and 1,272,720 carats of diamond recovered.

The CONSOLIDATED DIAMOND MINES OF SOUTH-WEST AFRICA produced 925,243 carats of diamond in 1959 from mining and prospecting. In the year 8,555,313 cu. metres of sand overburden was stripped, including 523,227 cu. metres for prospecting. In addition 699,015 cu. metres of cemented sand and calcrete secondary overburden were mined and dumped. The gravels mined and screened totalled 2,899,028 cu. metres of which 31,489 cu. metres were from prospecting. A new field screening plant was commissioned at Affenrucken and the 39G field screening plant was dismantled and re-erected at 122G. The new grease-belt recovery plant and differential mills came into operation during April and the new sort house in July. Prospecting continued under the direction of the consulting geologists and after allowing for depletion some 600,000 carats of diamonds were added to the estimated reserves.

Ghana.—The report of AMALGAMATED BANKET AREAS for the year ended September 30 last shows a profit of £118,660. After making various allowances a balance of £2,567 is carried forward. The ore milled during the year totalled 755,229 tons, from which 178,464 oz. of gold was recovered. Ore reserves at September 30 last are given as 936,542 tons averaging 5·704 dwt. in value.

WESTERN SELECTION AND DEVELOPMENT reports a profit of £133,867 for the year to September 30 last, a dividend of 8% requiring £45,938 of the £250,737 available.

Nigeria.—The operations of the BISICHI TIN CO. (NIGERIA) during 1959 resulted in a profit of £131,255 and of the £275,673 available a dividend equal to 6d. a share requires £71,841. In the year 486½ tons of tin concentrates and 342½ tons of columbite were produced. Earlier this month it was announced that the directors of the company had submitted to JANTAR NIGERIA the terms of an offer which it is proposed to make for the whole of the issued share capital of Jantar. At September 30 last the reserves of primary columbite on the Jantar property were given as 717 tons. Since then it has been announced that extensive drilling has been completed, with the result that the company's reserves of recoverable primary columbite are now calculated to be (in round figures) 4,000 tons of proved and 500 tons of possible mineral.

The accounts of the KADUNA SYNDICATE for 1959 show a profit of £15,683 and £30,702 available, of which dividends equal to 41⅔% require £12,250. The output of tin concentrates for the year was 195 tons.

KADUNA PROSPECTORS reports a profit of £3,486 for 1959 and a total of £8,358. Dividends require £3,573 of this amount. Output for the year totalled 47 tons of tin concentrates.

Belgian Congo.—During 1959 the copper production of the UNION MINIÈRE DU HAUT KATANGA at 280,403 metric tons exceeded all previous figures. It represents a large increase when compared with 235,586 tons for 1958 and is even considerably higher than the previous maximum total of 247,452 tons, recorded in 1956. A sharp rise in the demand for cobalt having manifested itself from the beginning of the year, production of this metal was raised to 8,431 tons, against 6,501 tons in 1958. The results of operations, favourably influenced by the above factors, permitted of a distribution of 2,732,400,000 francs—that is, 2,200 francs per full share.

Australia.—The operations of the CONSOLIDATED ZINC CORPORATION in 1959 resulted in a profit of £3,969,759. Dividends equal to 4s. on the ordinary shares require £1,247,748 and preference dividends £208,961. In his statement accompanying the report and accounts for the year the chairman, speaking of base-metal exploration, says that in the Broken Hill district of Australia geological studies were continued and limited drilling and other work have been carried out in a number of areas outside the mine leases without disclosing mineralization of economic value, while in the Northern Territory some drilling has been continued

on and near the low-grade lead deposit in the Rum Jungle area. The joint exploration programme carried out in association with MOUNT ISA MINES in the Northern Territory and Queensland has now been completed and in the Laloki area in Papua, in which the Corporation is interested jointly with NEWMONT MINING, drilling by the Papuan Administration has revealed interesting gold and zinc values in one hole. Drilling is continuing to search for possible extensions of the ore-body in which these occur. In Canada exploration conducted by the wholly-owned subsidiary company, the CONSOLIDATED ZINC CORPORATION OF CANADA, is being maintained in several sections of the Noranda District, while in other areas base-metal exploration has been continued on joint account with YUKON CONSOLIDATED.

In 1959 the ZINC CORPORATION treated a total of 667,660 tons of ore for a production of 81,930 tons of recoverable lead, 2,045,978 oz. of silver, and 111,873 tons of zinc concentrate, as compared with 659,268 tons of ore for a production of 79,098 tons of recoverable lead, 2,033,955 oz. of silver, and 115,348 tons of zinc concentrate in 1958. Also in 1959 NEW BROKEN HILL CONSOLIDATED treated 584,530 tons of ore for a production of 65,737 tons of lead, 1,785,540 oz. of silver, and 128,416 tons of zinc concentrate, as compared with 527,122 tons of ore for a production of 57,049 tons of lead, 1,498,434 oz. of silver, and 119,103 tons of zinc concentrate in 1958.

At an extraordinary meeting of NORTH BROKEN HILL on May 12, members approved of the resolutions necessary to complete the scheme of recapitalization of the company. As a result members now own five fully-paid shares of 10s. nominal value for each 5s. stock unit then held.

Last month the WESTERN MINING CORPORATION, as general managers for WESTERN ALUMINIUM N.L., announced that arrangements had been completed through Mitsubishi (Australia) Pty, Ltd., for the supply of three 10,000-ton trial shipments of bauxite to Japan from Western Aluminium's deposits in the Darling Ranges in Western Australia. One shipment will go to each of the three major aluminium-producing companies in Japan.

In an interim report issued last month shareholders of the LAKE GEORGE MINING CORPORATION are given little encouragement in the way of results from exploration work in hand. At present ore production figures are lower than for last year, the mine being expected to yield 16,500 tons per period for the remainder of this financial year. Several working faces in the middle section of the mine have been worked out and ore extraction efforts are being gradually concentrated in the more restricted areas on the lower levels. The grade of ore milled was low for the first half of the year, but has since improved, it is stated, and it is expected that the average for the rest of the year will approximate ore-reserve values. The recoveries of lead, zinc, and copper have been well maintained.

Malaya.—Last month the directors of GOPENG CONSOLIDATED announced that the holders of more than 80% of the issued share capital of TEKKA, LTD., had accepted the company's offer to acquire the issued share capital of Tekka and the offer has been declared unconditional.

India.—With the recent dividend notice shareholders of the Indian Copper Corporation are informed that the profit for the year ended December 31, 1959, was £1,202,259, out of which have been provided £175,000 for depreciation, £439,949 for taxation, £56,250 for development rebate reserve, and £125,000 for general reserve, leaving a profit of £406,060. With £71,312 brought in from 1958, the balance available is £477,372 and after providing £370,251 for the proposed dividend of 27% the balance carried forward is £107,121.

Brazil.—Last month the directors of ST. JOHN D'EL REY MINING COMPANY announced that, the necessary consent of H.M. Treasury having been received, the central management and control of the company has been transferred to the U.S.A. in accordance with the Authority given at the extraordinary meeting held on March 24.

Dominica.—The first 15,600 tons of iron ore of the total 480,000 tons contracted has been shipped to Ferrostal of Essen, Western Germany, from the Dominican Republic. Special arrangements, it is announced, have been made by the Dominican mining company to increase output following the German order. At present 1,000 tons are being extracted daily from the Hatillo mine and deposits at Mogote and Laguna, which will soon start production, will provide a further 900 tons daily.

United States.—The GOLD FIELDS AMERICAN DEVELOPMENT COMPANY, a wholly-owned subsidiary of the CONSOLIDATED GOLD FIELDS OF SOUTH AFRICA, announced last month that an agreement had been reached in principle between its wholly-owned

American subsidiary, TRI-STATE ZINC, INC. and AMERICAN ZINC, LEAD AND SMELTING COMPANY, whereby American Zinc will make available to Tri-State a tract of mineral lands located near New Market, Jefferson County, Tennessee, for developing and mining zinc ore. American Zinc has indicated by diamond drilling a reserve estimated at approximately 1,000,000 tons of high-grade zinc concentrates on this property. Tri-State has agreed to complete development by diamond drilling to prove the indicated reserve and thereafter to start the necessary sinking of shafts or incline to bring the mine into production.

Rio Tinto Company.—Last month the Rio Tinto Company announced that it had joined forces with the leading German metallurgical group, Deutsche Gold- und Silber-Scheideanstalt (Degussa), to form Nuklear-Chemie und -Metallurgie Gesellschaft m.b.H. (NUKEM). Degussa is the only private manufacturer of nuclear fuel elements in Germany and has had considerable experience in the processing of rare metals and compounds. Mallinckrodt Chemical Works, through its subsidiary, Mallinckrodt Nuclear Corporation, a leading producer of enriched nuclear fuels in the United States, is also a shareholder and has concluded a technical collaboration agreement with NUKEM providing for exchange of information on the processing of nuclear fuel materials. NUKEM will take over the existing research and production programme of the Degussa Nuklear Gruppe. This programme covers a wide range of uranium and thorium processing and fabricating activities related to the nuclear programmes of a number of countries. NUKEM is to co-operate closely with Rio Tinto's uranium mining interests and with RIO TINTO DOW, LTD., a company specializing in uranium and thorium processing.

DIVIDENDS DECLARED

*Interim. †Final.
(Less Tax unless otherwise stated).

†Ampat Tin Dredging.—30%, payable July 1.
***Anglo American Investment Trust.**—7s. 6d., payable Aug. 4.
†Bremang Gold Dredging.—15%.
***British Aluminium.**—4%, payable June 1.
†Central Mining and Investment Corporation.—3s. 6d., payable July 8.
†Central Norseman Gold Corporation.—1s. 9d. Aust., payable June 24.
†Coley Metals.—15%.
***Consolidated African Selection Trust.**—9d., payable June 24.
Consolidated Co., Bullfontein Mine.—Half-yearly 7d., payable July 28.
***Consolidated Diamond Mines of South-West Africa.**—Pref. 4½d., Ord. 5s., payable Aug. 15.
***Consolidated Gold Fields of South Africa.**—1s. 3d., payable June 30.
De Beers Consolidated Mines.—Pref. 10s., payable July 28.
Griqualand West Diamond Mining.—Half-yearly 2s. 10d., payable July 28.
†Henderson's Transvaal Estates.—6½d., payable July 29.
†Idris Hydraulic Tin.—6½%, payable July 15.
†Indian Copper Corporation.—27%, payable Aug. 31.
***Kampong Lanjut Tin Dredging.**—3s. 6d.
†Kramat Tin Dredging.—2s. 6d., payable June 22.
†Kuala Kampar Tin Fields.—3s. 6d., payable June 15.
†Lower Perak Tin Dredging.—1s. 6d., payable June 29.
†Minerals Separation.—8d., payable July 8.
Mount Morgan.—Pref. 3½%, payable June 30.
***Mufulira Copper Mines.**—2s. 7½d., payable July 1.
New Jagersfontein Mining and Exploration.—Half-yearly 6d., payable July 28.
***Orange Free State Investment Trust.**—2s., payable Aug. 4.
***Rand Selection Corporation.**—1s., payable July 20.
Rhodesia Copper Refineries.—Pref. 2½%, payable June 30.
***Rhodesian Selection Trust.**—6d., payable July 1.
Rhokana Corporation.—Pref. 2¾%, payable June 30.
***Roan Antelope Copper Mines.**—4½d., payable July 4.
†Selection Trust.—5s. 3d., payable July 9.
***Siamese Tin Syndicate.**—1s., payable July 15.
***Turner and Newall.**—5%, payable July 16.
†Tweefontein Investments.—6s. 6d., payable July 14.
***Union and Rhodesian Mining and Finance.**—8⅓%, payable June 30.
***West Rand Investment Trust.**—1s. 3d., payable Aug. 4.

METAL PRICES

June 8.

Aluminium, Antimony, and Nickel per long ton; Chromium per lb.; Platinum per standard oz.; Gold and Silver per fine oz.; Wolfram per unit.

	£	s.	d.
Aluminium (Home)	186	0	0
Antimony (Eng. 99%)	190	0	0
Chromium (98%–99%)		7	2
Nickel (Home)	600	0	0
Platinum (Refined)	30	5	0
Silver		6	7¼
Gold	12	10	6½
Wolfram (U.K.)		—	
(World)	7	18	6

Tin, Copper, Lead, Zinc } See Table, p. 376.

Oil Sands of Alberta

H. L. Holloway, A.M.I.M.M.

The "tar" sands of the Athabasca River, Canada, and their possible future

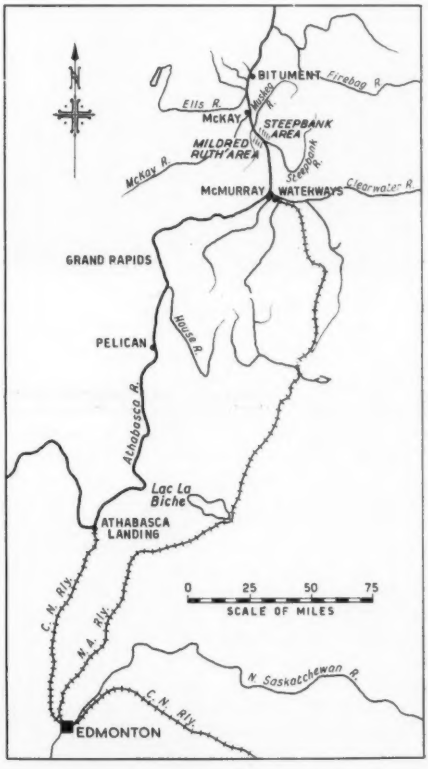
Introduction

The existence of tar sands, as they were first called, along the Athabasca River was first noted by the early explorers of this section of Northern Canada, the bituminous "cut banks" along the course of the river being too conspicuous to escape notice. They were a familiar sight to the crews of the scows, mainly French half-breeds, who piloted and portaged supplies into the Mackenzie district by way of the Athabasca, the only practicable freight entrance to the Northwest Territories from Edmonton. The potential wealth shut up in the sands preoccupied politicians and finance groups from an early date and to the more optimistic the chief problem was one of access, the difficulties of extraction and treatment being often underestimated.

It was the possibility of solving the problem of access which to a considerable extent influenced plans to construct a railway from Edmonton to McMurray in the years immediately preceding the first World War. River transport from McMurray upstream to Athabasca Landing, 96 miles north of Edmonton, was unsatisfactory because of the series of rapids in summer and of the freeze-up in winter. At that time the district was a completely pioneer one, the only activity apart from trapping being in the transit camps for freight and trade along the river course. The pioneer condition has not altered greatly to-day, although with the multiplification of freight traffic due to mining and military activity in the north, the camps along the river have grown into settlements and small towns. The oil sands have engendered activity and lumber camps exist, but a few miles away from the river one is in primeval forest which stretches to the west away to the Peace River and thence again to the Rocky Mountains and to the east to Hudson Bay. There is still a huge "Last Great West" here waiting for population and for development of its potential wealth.

Geology

The oil sands exposures occur over a wide area in the McMurray district along the Athabasca and its tributaries, commencing about 40 miles south of McMurray and continuing to the north for some 115 miles;



Sketch Map of the Athabasca River.

An Oil-Sand Bank.

McMurray is situated 230 miles north-north-west of Edmonton. Outcrops have been noted and mapped over an area of approximately 1,500 sq. miles, but drilling has shown that this is only a small proportion of the extent of the deposits, the total area having been variously estimated at from 8,000 sq. miles to 30,000 sq. miles. While overburden is light where the strata are sufficiently high to outcrop along the river banks, drilling data as analysed by the Research Council of Alberta (1) [1] in a Report in 1955 gives the following proportional depths to known deposits over an area of 2,500 sq. miles: 0 to 150 ft. of overburden, 800 sq. miles; 150 ft. to 500 ft. of overburden, 800 sq. miles, and 500 ft. to 1,000 ft. of overburden, 900 sq. miles.

In the vicinity of McMurray the overburden consists of Pleistocene and recent deposits while in some other districts Lower Cretaceous marine shales of the Clearwater formation lie over the oil sands. The bed upon which the sands lie is Upper Devonian limestone and limey clay of the Waterways formation. The Devonian limestone is exposed at the base of the oil sands in some of the Athabasca River exposures. The sands themselves are of Lower Cretaceous age of the McMurray formation. Thickness of the beds along the Athabasca is from 150 ft. to 200 ft., but there is much interstratification with other sandstone, clays, and shales, with some thin lignite seams.

Following intense orogenic activity during late Jurassic or early Cretaceous times a marine trough developed across Western Canada and this trough was covered by transgressive seas lying on Palæozoic or early Mesozoic formations. Along the borders of these seas the sediments of the McMurray formation were laid down, changes in the shore line, in surface configuration, and in precipitation inducing changes in the rate and in the nature of sedimentation. The sand in the oil sands appears to have been derived from the Pre-Cambrian Shield rocks to the east and the beds were laid down as a shore-line deposit at the edge of the Shield, often apparently under deltaic conditions, resulting in interstratification with beds and lenses of silts and clays with great variation in sequence. To the west of McMurray the oil sand beds would seem to thin out somewhat rapidly, although drilling has shown occurrences 100 miles to the west, as also 75 miles to the south. A great deal more exploratory drilling is necessary to determine the actual boundaries of the deposits.

The origin of the oil, as might be expected, gives rise to much geological controversy out of which two main schools of thought have developed. The one (2, 3) favours the theory that the oil content originated locally and formed in its present heavy, and geologically young, character in the actual McMurray formations. The second theory (4, 5) is that the oil has migrated from Devonian rocks during, or subsequent to, the laying down of the Lower Cretaceous beds, becoming in the process more viscid through oxidation and evaporation. The controversy does not lack warmth in presentation of opposing theories,

[1] Figures in parentheses refer to the bibliography at the end of the article.

Scows on the Athabasca.

but it would appear that the migration one is gaining ground.

The sand which forms the beds in the areas of outcrop is mainly of quartz ranging largely from *minus* 50 to *minus* 200 mesh with accessory minerals including mica, ilmenite, tourmaline, zircon, spinel, garnet, rutile, and pyrite. Where lower than *minus* 200 mesh, clay and silt increase and the oil content decreases. This oil content in the better sands is from 10% to 17% with water from 2% to 8%. The oil is viscous with a specific gravity of from 1·005 to 1·025. The sulphur content of the oil is from 4% to 7%. As found, the oil sands weigh some 210 lb. per cu. ft. Lignite particles occur in the parting planes of the seams and carbonized trees have been found in them. Over the whole area a 6% oil content is accepted as an average of potentially exploitable deposits.

Exploration

The first actual drilling appears to have been carried out by the Geological Survey of Canada as long ago as 1897–8 at Pelican Rapids, 85 miles south-west of McMurray, where the oil sands were overlain by 740 ft. of overburden. The idea inducing the choice of this site was that the oil contained in the sands at greater depths might approximate more closely to that found in normal oil wells, but this idea was not substantiated by results. The borehole was blown up by gas but samples of the oil and of the bituminous sands were obtained.

Some further drilling was done in the late 1920's by S. C. Ells (6, 7) [1] and little more until 1943, when war-time needs inspired the attempt to develop local sources of petroleum fuels to supplement those from known oilfields in the Province.

With the ending of the war and the discovery of the rich Leduc oilfield in 1947 the urge to solve the difficult technical problems involved in exploitation of the oil sands declined, although experiments were still carried on. The drilling programme initiated in 1943 under the Department of Mines and Resources (8) continued until 1947. Maximum

[1] Ells, S. C. The Mining Magazine, June, 1936.

Banks of Oil-Sands Resting on Limestone.

depths drilled were 300 ft. with average depths of 185 ft., the drilling being confined to shallow deposits along the Athabasca River with the idea of finding good-grade sands which could be worked by open-cast methods. The rig used was a modified diamond drill. The drilling demonstrated the variation of the strata in its nature and thickness and in oil content, but an area was found corresponding to the conditions desired in the Mildred-Ruth Lake deposit where a block totalling 4½ sq. miles was proved containing 1,162,665,000 tons of oil sand averaging 13·6% oil. This gives a total of 900,000,000 barrels of oil (a barrel holds 35 Imperial gallons). The greatest seam thickness was 224 ft. and overburden was between 30 ft. and 60 ft.

Another good area has been proved in the Steepbank locality on the east side of the river immediately opposite to Mildred-Ruth and still another on the Firebag River, the latter deposit being estimated to contain 1,000,000,000 barrels of oil. In the 1950s private oil companies carried out a considerable amount of exploration on their own account. Private activity was inspired to a large extent by the favourable opinions as to the possibility of economic exploitation of the deposits expressed in the Blair (9) Report in 1950, mentioned later in this article.

Exploitation Experiments

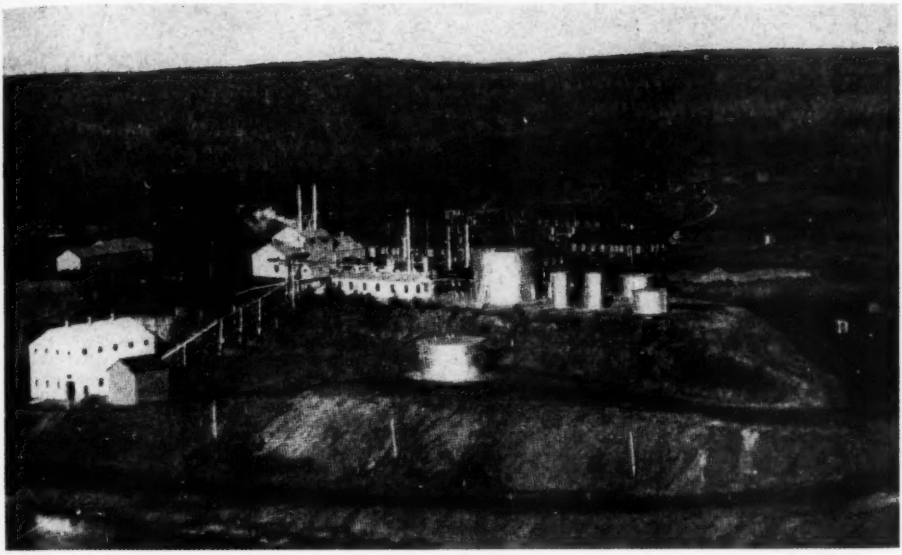
Two separate problems are involved in the exploitation of the deposits, one of mining by open-cast methods the shallow high-grade occurrences and the other of extraction *in situ* of the oil from deeper and often lower grade occurrences.

Experiments have been made in using the bituminous sand as it occurs in exposures for the purpose of road-making. In 1913, before the construction of the Northern Alberta Railway to Waterways, near McMurray, a quantity of the oil sand was brought to Edmonton and, with added mineral aggregates, was used for road paving. A further experiment was made on a larger scale in 1926–7 (10, 11) and the physical results were apparently successful in both cases but costs, chiefly of transport, ruled out the wider utilization of the oil sands for road construction.

As long ago as 1920 the Research Council of Alberta investigated the possibility of separating the oil from the sands in laboratory experiments with hot-water washing and it was found that the oil separated readily from the sand host. To eliminate the expense involved in heating great quantities of water cold-water separation was later tried and a recovery of 95% obtained, but with a more complex treatment (12, 13). Continuous retorting was also experimented with by the National Research Council of Ottawa (14, 15) and an 80% recovery was obtained on a small scale in a distillate of 16 A.P.I. gravity.

Plants have been built in the oil-sands outcrops areas by Government departments and by owners of concessions with emphasis on the hot-water separation method. The first plant was built by the Research Council of Alberta in 1929–30 (16, 17). Private interests were responsible for the construction of further plants in the 1930's and an appreciable quantity of oil products was produced and sold (18), but presumably because of the expense of water heating no major production was attained. In 1945 the Government of Alberta, on designs of the Research Council of Alberta (19, 20), made plans to build a separation plant at Bitumont. This was completed in 1949 and gave satisfactory results, the methods used including a more economical production with improved utilization of heat. The plant treated approximately 500 tons of the oil sands per day. The plant, with an adjoining lease, was later sold to the Can Amera Oil Sands Development Company.

Under the auspices of the Government of Alberta, associated with some private companies, a study of all known facts and hypothesis relating to the oil sands was made and in 1950 a report, known as "The Blair Report" (9), was published and attracted a good deal of attention in oil circles. This report established that the extraction, treatment, and transport of oil from the oil sands was a commercial proposition. Free of interest on the mining capital employed, it was estimated that oil could be delivered in Edmonton by pipeline at a cost of $2.36 per barrel. As a basis for comparison the crude oil prices per barrel in Edmonton in succeeding years was some 8 cents dearer, but after allowing a working profit and interest on capital investment to the producers. The broken-down costs were estimated as follows: Strip mining, including removal of overburden, $0·55; hot-water separation of oil from sand, $0·72; desulphurization of fluidized coker distillate by mild hydrogenation, $0·81; pipeline transport to Edmonton, $0·28—a total of $2·36. The products were approximately 15% naptha and 85% No. 2 furnace oil of 26° A.P.I. gravity.



Pilot Plant at Bitumont.

Following the Blair Report various concessions were taken up chiefly on the west bank of the Athabasca. An Oil Sands Conference was sponsored by the Government of Alberta in 1951 where all aspects of the problems relating to the deposits were discussed by experts in various branches of oil technology (21). By 1957 the Royalite Oil Company had proved a billion barrels of oil on its Mildred-Ruth Lake property. This company has studied the application of a centrifugal technique for the extraction of bitumen from the sands. The oil as produced would need up-grading from its low 10° A.P.I. gravity and desulphurization before being suitable for pipeline transport and this the company hopes to achieve by 1960. Thus a major exploitation of the oil sands in areas of shallow overburden appears to be in sight.

Much thought has been given to the exploitation of the deeper oil-sands deposits. The oil is too viscid and lacks the gas pressure to induce it to flow into drill-holes as in normal oil wells. The interstratification with other beds of low-grade or barren sands and with shales, etc., is a further complication. The Magnolia Petroleum Company has tried out a method of underground combustion on similar deposits and this is a possible system of extraction (22). It is unlikely, however, that much will be done until the more easily worked shallow beds have been developed on a commercial scale.

A restricted market for oil products exists in the minefields and aviation camps in the Canadian North, as also in such other Settlements as may be built-up there, but any major oil production must be based on pipeline transport to an outside market, which in the case of the Athabasca district means Edmonton. To justify a pipeline of the necessary length an economic quantity of oil must be available and, as the product in its primary low-grade state is too viscid and too loaded with sulphur, treatment for up-grading and freeing from sulphur will be necessary before being pumped to a market.

Regulations Regarding Disposition of Bituminous Sands Rights

Maximum area of a Prospecting Permit : 50,000 acres.

Maximum number to be held by one person : two.

Fee payable on application : $250.

Rental for first year : 5 cents per acre.

Rental for second and third year if extended : 10 cents per acre.

Deposit : $50,000 (refundable).

Granting and renewal at discretion of Minister of Mines, who must be satisfied of legitimate aims and satisfactory standing of applicant.

Leases.—For 21 years after Minister is satisfied as to development plans. Rental : 25 cents per acre for first five years and $1·00 thereafter, which may be reduced to 25 cents if not yet in production.

Royalty.—On each of products derived from bituminous sands, not to exceed one-sixth of such products. On bituminous sands sold without processing. Not defined.

Cash deposit on a lease, $5·00 per acre with maximum $50,000 and minimum $10,000.

All deposits repaid if lease surrendered after compliance with the terms and conditions under which it was granted. Deposit refunded also upon completion of plant construction.

In conclusion grateful acknowledgment must again be made to the staff of the Research Council of Alberta who furnished the information upon which this article has been built.

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British Mining Equipment Export Association

In the MAGAZINE for September last reference was made to the formation of a "Mining Machinery Manufacturer's Export Association," intended primarily to help firms too long dependent on the coal industry as a market for their products. Negotiations over the past few months have now brought this project actively into being, the "British Mining Equipment Export Association" having been formally constituted last month. This Association, with a present membership of 33 firms has, it is stated, been formed to tackle export problems *vis-à-vis* Government and financial agencies at home and overseas and to provide facilities for collective market intelligence and sales promotion. The Association recognizes that mining is vitally important, especially in the developing countries, and that the export market for mining equipment is increasing, but feels that organized competition from other industrialized countries is severe. It is felt that there has been a lack of co-ordination between those in the Government and in the City who seek to extend British political and economic influence both within the Commonwealth and in the politically uncommitted areas of the world and important that the machinery manufacturing industry should establish and maintain closer liaison with other groups of interest both in Britain and overseas upon whom depend the creation of new export sales opportunities. To this end it may be necessary collectively to undertake market research and to promote positive sales activities.

The new Association at this early stage in its development is obviously dependent on the keenest support from manufacturers. Without it, it cannot succeed. At the same time there is recognition that such support is not all that is needed. For too long the British consultant has been fighting a battle for recognition too much on his own. He, too, needs closer support from Government, such support as is readily available to practitioners of other than British nationality. Somewhere these two interests must coincide and in the first instance we can only hope that the Association will get the support it certainly deserves.

Mineral Processing in Review [1]

An assessment of the main points raised during the recent Congress

E. J. Pryor, A.R.S.M., D.I.C., D.Sc., M.I.M.M.

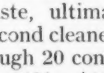
Session IV—Flotation Practice

(*Papers 19–23*)

For this session the chair was taken by Professor W. Gründer, the papers, which dealt with lead ores, ilmenite, brown iron ores, and the separation of feldspar and mica, being introduced by Professor M. Rey.

The first paper to this session (19) by K. S. Blaskett gives an interim report on the use of gangue depresants in floating a lead sulphide ore. These included ligno-sulphonates, tannins, dyes, guar gum, and pH modification with sulphur dioxide. The ore contains fine-grained galena in slates and schists with some graphite and much sericite and chlorite. The sericite floats readily, particularly in alkaline pulp. The depressants were principally effective on the silicate gangue but some also acted on pyrite and graphite. Silicate depression was very sensitive to amounts of depressant used. The author suggests that sericite develops hydrophobic coatings in the presence of sulphydric collectors and thus becomes floatable.

A new flow-sheet for the successive flotation of pyrite and ilmenite from a pulp tail after magnetic separation has removed the magnetite was then described in Paper 20 by O. Eidsmo and Dr. O. Mellgren. The key to success lay in reconditioning the ilmenite rougher float before each of the three recleaning flotations, at 70% solids. Tall oil, the collector used together with fuel oil, is treated in an emulsifying machine, perhaps with an emulsifying agent, and recovery is improved by working on a deslimed pulp. Crude tall oil provides its own emulsifying agent, the fuel oil acting as a froth modifier. The ore deposit of 350,000,000 tons assays 39% ilmenite and 2% magnetite. Crude tall oil with its 50% or so of fatty acid is cheaper than once-distilled oil at 85% and consumption is similar for equally good recovery. An equal mixture with fuel oil is used. Use of a polyglycol ether (Extoxol AP-19) as an emulsifying agent has some value since a lower pH can be used with better depression of the apatite in the pulp, but conditioning time must be 50% longer. A useful method of measurement of the efficiency of emulsification of the reagents is described. The apatite is dealt with partly by flotation before raising the ilmenite and partly by depression in the cleaning stages with fluorine ions.

V. Runolinna, R. Rinne, and S. Kurronen in Paper 21 describe the agglomeration-flotation of ilmenite without preliminary desliming. The feed after removal of magnetite and pyrite carries 38% ilmenite, 30% hornblende, 21% chlorite and mica, 10% plagioclase, and a little magnetite, apatite, and pyrite. In the earlier flow-sheet slimes were classified out and run to waste, ultimate ilmenite recovery being 74% (second cleaner). Instead the pulp now goes through 20 conditioners in series and recovery is 88%. Attrition conditioning used over 10 kWh./ton as against the more gentle action of impellers at 5 kWh./ton for similar recoveries. The tall oil does not spread readily on the mineral surfaces and this makes prolonged and thorough conditioning essential. Agglomeration is completed by a relatively rapid spread of fuel oil on the tall oil-coated ilmenite particles. Fuel oil is also a mild depressant for silicates and helps to form a brittle, free-draining froth. The emulsifying agent used is an alkyl-phenol-polyglycol-ether, R—  —$(OC_2H_4)_{11}OH$ marketed as Etoxol P-19. It reduces the energy required for conditioning, accelerates ilmenite agglomeration, and helps to improve the froth. Fuel oils atmospherically distilled with an aniline point between 145° and 163° F. and over 10% of aromatic hydrocarbon give the best results.

The next paper (22), by Z. S. Bogdanova, S. I. Gorlovsky, and B. M. Lakota, summarizes flotation research on manganese and limonite ores, using collectors based on fatty

[1] (*Concluded from the May issue, p.* 278.)

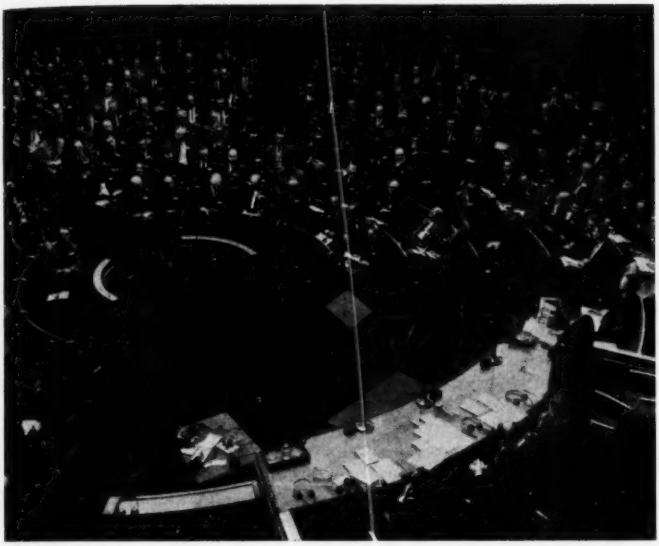
acids, cationic reagents, oxidized white spirits, etc. Laboratory success on manganese slimes and low-grade limonite has been confirmed in practice. Sulphate soaps and tall oil (crude, distilled, and fatty-fraction) were found of considerable interest. As these have already been described, the authors give some details of the reagents produced by oxidation of hydrocarbons. Five groups of products are made: (1) Water-soluble carboxylic acids, aldehydes, alcohols; (2) " hydro-carboxylic acids " insoluble in petroleum ether; (3) compounds insoluble in benzene; (4) ethers, esters, high alcohols, and aldehydes, and (5) organic acids (" carboxylic ") soluble in petroleum ether. Groups 1, 3, and 4 are poor collectors. Group 2 are very active but hard to standardize in production. Group 5 includes the R.COOH-type acids, R.COOR. COOH-type ester-acids, etc., produced from " white spirit," a petroleum fraction which boils in the 145–205° C. range and is a mixture of paraffin with up to 10% of napthenic and aromatic hydrocarbons; kerosene, petroleum and " soft paraffin " (a mixture extracted from petroleum by urea and isopropyl alcohol), and " recycle " (a hydrogenation product of unsaturated hydrocarbons, boiling from 130° up). Of these, white spirit, kerosene, recycle and soft paraffin with acid values between 40 mg. and 60 mg. KOH appear best. For iron flotation the residual bottoms from distillation of black cotton-seed soap stocks is the most selective addition to these oxidized hydrocarbons. The paper continues with details of reagent plans and treatment details which led to such results as limonite concentrates assaying up to 46% Fe with recoveries of 80% from 30% Fe feed and of rough concentrates carrying over 20% manganese from a *minus* 10-μ feed assaying 13% Mn, with 95% recovery on the laboratory scale. These were followed by higher grades with lower recovery on the plant scale.

Finally, Paper 23, by J. N. Wilson, describes the separation of feldspar from mica by flotation. The feldspathic sand is used as a flux in the ceramic industries. Coarse flake mica is removed by table flotation on liberation and the final mica content of the spar must not exceed some 0·5%. Mill discharge is pumped to an 18-mesh screen which delivers oversize to a pair of Holman-Michell agglomeration tables. Tails return to the mill and rougher concentrates are upgraded by further agglomeration. The screen undersize is mechanically deslimed. Sands from this are split by screening and sent either to table agglomeration or to froth flotation. The final feldspar concentrate assays 16·7% potash feldspar, 36·7% soda feldspar, 3·4% clay, and 42·6% SiO_2. The mica product consists of about 90% muscovite and 10% biotite. Armac T is the cationic flotation reagent used in a pulp held at pH 4·6 with H_2SO_4; 4 lb./ton of light fuel oil is used in the first stages of table flotation. The paper gives details of economic interest.

Session V—Gravity and Dense Media Separation (*Papers 24–30*)

The second day of the Congress opened with Session V, the chair for which was taken by Professor I. N. Plaksin. The seven papers to be covered were introduced by Dr. C. R. Burch. These were concerned with " Gravity and Dense Media Separation," subjects of increasing industrial importance in modern practice.

Paper 24 by Dr. G. D. Lill and the late H. G. Smith presents a laboratory study of jigging in which the minerals were transparent and immersed in fluids of corresponding refractive index—glass chips in benzene and fluorspar in paraffin. This technique was used to facilitate study of opaque particles in the transparent beds thus formed in a diaphragm batch-operated jig worked at full suction. Visibility was good in the centre of a close-sized 4 in. by 4 in. bed. The density of each liquid was 0·8 and those of glass chips 2·6, glass beads 2·54, and fluorspar 3·1. Tests studied the effects of speed on separation in relation to (*a*) jigging speed, stroke length, and bed thickness and (*b*) size, shape, and density of penetrating particle. Observations were conducted in a space free from frictional retardation (wall effect) at sides of the jig box. Jig speed was varied between 40 and 300 strokes per min. and stroke lengths between 1·0 cm. and 2·5 cm. When the bed moved it was lifted entirely and settled out from the bottom upward under the loosening influence of a rising wave, which did not always reach the top layers. Separation of two minerals over a wide size range in one operation was achieved but when density difference was small the rate of separation was slow. The tests do not confirm Richards's hindered-settling theory or Hirst's theory of interlocking beds. There is an optimum jigging speed. The tests establish relationships between mean speed of separation, particle size, and density for material of regular shapes. Progress in understanding must rely, it is evident, on statistical studies.



The Congress in Session.

World Mining.

In the following paper (25) Professor H. Kirchberg and Dr. W. Berger give the results of studies of the movement of ore in an oscillating trough and of tests on a shaking table. The trough, which was 5 cm. wide and 27 cm. long, oscillated sinusoidally along a horizontal axis and was supported on horizontal rolls. Using specially developed measuring devices the relation between stroke length, oscillation frequency, and commencement of loosening of mineral was studied for particles of various sizes, shapes, and densities. With increase of depth of bed, particle size, or mineral density it was found desirable to increase the length of stroke. Bed permeability also increased with a lengthened stroke. There was evidence of a poorly-loosened central layer. This work, with the further tests on a shaking table of material in the middle of the size range normally treated, led to the following conclusions:—Particles move as layers save when wall effects are present and there is but little exchange between layers similar in size and density. The main forces at work are intergranular friction, fluid friction, and particle inertia. A limiting acceleration must be exceeded before a bed will loosen. The inertial function then changes and bed motion does not follow that of the trough. Frictional effects varied with amplitude and frequency of trough movement. Best results followed use of a large-amplitude and low-frequency oscillation to reach critical acceleration. If amplitude was insufficient the top and bottom layers became free while the centre remained compact. Increase of particle size speeded up the relative settling rate of the heavy mineral through the light. Fine particles passed readily through the voids of the loosened bed while coarse ones, even if heavy, had a poor chance of working down and staying down.

Efficiency studies in the concentration of diamonds by dense-media treatment are then covered in Paper 26 by A. C. Nesbitt and R. G. Weavind. The specific gravity of the diamond is 3·5, but 90% of the associated mineral is below 2·8 and 99% is lighter than the diamond. Ratio of value to gangue in a South African kimberlite pipe is of the order 1/15,000,000 and only 15% of the world's production is of gem value. Diamonds larger than 25 mm. are very rare, so the usual feed size is in the range $25 > 0{\cdot}5$ mm. Recovery of very fine diamonds is rarely economic. Efficiency in gravity concentration is judged by the Tromp curve, which here is related to the " probable error " in recovery of heavy fraction. The separating liquid used is lead sulphamate at densities up to 3·8. Density of the dense medium is controlled by a locally-developed bubble-pipe system which is correct to 0·01 of the specific gravity measured. Viscosity is measured by

means of a vertical cylinder rotated in the media by a falling weight, the angular velocity being an inverse function of viscosity. It is also measured by an instrument which monitors the trajectory of its discharge through a horizontal tube. For *minus* 4-mm. *plus* 2-mm. particles a change in media viscosity from 16 centipoises to 30 cP changed the probable error from 0·09 to 0·32. Investigation showed viscosity of ferro-silicon media to depend on (*a*) concentration, size, and shape of the FeSi particles; (*b*) nature, quantity, and sizes of contaminants; (*c*) degree of magnetization of the FeSi, and (*d*) the temperature. For operating densities above 3·0 spherical particles are necessary. The main contaminants are magnetite and kimberlite silicates. FeSi from magnetic cleaning goes to a cyclone, the overflow of which is classified in a densifier. The return product from this is demagnetized, screened on 28 mesh to reject oversize silicates, and tabled to reject a band containing 1% FeSi. Removal of this, together with the *plus* 28-mesh materials, brings down the viscosity in the cones from 45 cP to 25 cP.

Paper 27, by Professor P. Moiset and Professor R. Dartois, describes a magnetic valve used in place of the conventional dense-media air lifts to remove a non-magnetic sinking product. The device provides a controlled magnetic field round the underflow, which acts on the ferro-magnetic media to produce a retarding stopper through the weak centre of which the non-magnetic concentrate forces its way. Remote control, perhaps aided by closed-circuit television, is possible. The power used is below 0·5 kW. and depends on the static pressure and effective cross-sectional area controlled. Precision of separation between 1-mm. and 15-mm. sizes is being achieved.

Then, in Paper 28, by Dr. E. Cohen and R. J. Isherwood, a series of cyclone tests and their support of theoretical concepts concerned with feed volume and rate, apex discharge, cyclone dimensions, etc., is described. The work was primarily concerned with the use of their cyclone as a dense-media separator but some of the findings have more general value.

Pressure of feed into the cyclone is hardly considered relevant but rate of feed is of major importance, since it determines the quantity presented and its kinetic state. The authors consider that constant-volume pumps should be used since delivery by a centrifugal pump would be greatly affected by wear, pressure change, and variation in pulp density or viscosity. Any of these factors might be at work without producing a visible pressure change. These are among ten concepts tested by means of a closed circuit comprising a 2-in. Mono pump, a 3-in. hydrocyclone, and a holding tank equipped with mechanical stirring. The cyclone, set horizontally, has a 60° cone angle, which had been found in preliminary work to give a free-spray discharge as against the "ropy" one with a 30° angle. In closed-circuit work a vertically-set cyclone was found unsatisfactory. The test material was a synthetic mixture of quartz and chromite, both chemically inert and tough. They were sized to *minus* 20 *plus* 36 mesh B.S. The dense medium used was atomized *plus* 200-mesh ferro-silicon for the earlier work and nominal *minus* 20 μ and *minus* 10 μ at later stages. The results of a series of tests described in detail may be condensed thus: (1) Optimum feed rate must provide sufficient centrifugal force to direct all heavy values to the underflow. (2) The FeSi (or other medium) must be fine enough to stay in suspension and follow the flow of water. To reduce viscosity effects something lighter is suggested—*e.g.*, barytes of S.G. 4·0, usable at a coarser size. (3) Rate of feed of material destined for the underflow determines the correct size of apex discharge. (4) The vortex finder must be large enough to discharge all non-underflow material. (5) These considerations presuppose a maintained constant feed. If it rises the apex is overloaded; if it falls overflow material reports with apex product.

Other conclusions reached were that in dewatering work the apex orifice must be no larger than will pass the solids with a minimum volume of water, at a feed rate fast enough to centrifuge down the desired solids. The vortex finder must handle the balance without risk of back pressure. A constant volume of pulp constituents is, with constant volume of the feed itself, essential. The paper concludes with a discussion of design factors for a given purpose.

Developments in the estimation of values in cassiterite-bearing gravels and with the possible improvement of standard methods of recovery, notably by the use of low-pressure cyclones ahead of jigging, are dealt with in Paper 29 by I. R. M. Chaston. The traditional methods—jigging and sluicing—accounted respectively for 51% and 41% of Malaya's tin recovery in early 1959. Recovery figures related to valuation by panning are

misleading since they are usually only true for two size brackets (*plus* 30 mesh and *minus* 100 *plus* 20 mesh B.S.). Comparison with a total tin assay shows that hand panning gives a low figure even when work is confined to *plus* 300-mesh sands. A flow-sheet, a diagram of the low-pressure cyclone incorporated in it, with operating costs and recoveries, together with comparison between palongs and the cyclone-jig combination point the way to possible improvements.

The last paper in this session (30), by Drs. A. Baniel and A. Mitzmager, deals with the possibilities of commercial dense-media separation in tetra-bromo-ethane (TBE), a liquid of S.G. 2·963 now becoming available at prices not mentioned but which are said to be competitive in the field of work covered by this and lower densities. Precise control, low solubility in water, and low drag-out loss are claimed.

Session VI—Magnetic and Electrical Separation : Sorting (*Papers 31–38*)

At this session the chair was taken by M. Pierre Seyer, Dr. E. Cohen introducing the papers, the first of which (31), by F. D. De Vaney, considers the enormous increase in the use of magnetic separation during the last five years for iron-ore concentration and describes the machines used, with their performance. Furnace burdens containing over 60% Fe show substantial savings and increased production. This, with the availability of high-grade ore from South America, has killed the market for natural 48% Fe ores with 10% silica. Low-intensity wet magnetic separators working to concentrate magnetite are in greater use. Of the two main types, drum and submerged belt, the drum wet separator predominates. It has from three to seven fixed poles of alternate polarity in a stainless-steel rotating shell and treats *minus* ¼-in. feed. Five-pole machines are preferred for roughing (cobbing) with electro-magnets having a field of 700–800 gauss (measured 2 in. from the shell) and 400 gauss for finishing. Use of permanent magnets has gained ground since 1955. In coarser sizes of ore the submerged-belt machines, notably the Crockett, are still in wide use.

In the 4-in. to ¼-in. range dry magnets are widely used in North America, worked at 600 gauss (measured 2 in. from the belt). The necessity for heating to ensure complete dryness, the need for restricted size ranges in the feed, and the dust problem are cost factors restricting dry concentration. High-intensity treatment of hematite and limonite as practised at Salzgitter is not used in North America. High-tension methods are, however, growing in the U.S.A. for ilmenite recovery from black sands.

Paper 32 by Professor P. G. Kihlstedt and B. Sköld describes research work on the development of a dry magnetic separator with permanent magnets. By balancing centrifugal force against magnetic attraction at a controlled drum speed ore can be fractionated into tailings, middlings, and concentrate, whereas in wet treatment a middlings product cannot be made. The first stage in dry treatment is therefore to produce two finished products. Operations are of two types—coarse concentration on feeds above 5–10 mm. for furnace lump ore and fine feed below 3–5 mm. for sintering. The Mortsell separator is developed from the old star magnet at the Royal Institute, Stockholm, in which permanent magnets rotate about a horizontal axis below a feed trough. It consists of a drum which rotates about a number of magnets fixed radially about a fixed axis. They have alternating polarity and a field of strength of up to 1,000 gauss at drum surface. The drum is made of a plastic material incorporating glass fibre. For material of *minus* 3-mm. size a three-drum separator has been developed, the first two pinning all magnetic material and the third upgrading this product. Tests are detailed with resulting conclusions.

S. Eketorp (Paper 33) then describes the reduction of iron ores by roasting in a recuperative furnace. The author calls this "magnetic roasting." The furnace has a tubular heat exchanger and oil fuel consumption is 500,000 B.Th.U./ton of ore, treatment costing approximately $1·50 per ton. It is advantageous to treat relatively fine ore (1·5 mm. to 2 mm.) which, by reason of its larger specific surface and more gentle movement, reacts quickly and is less abrasive.

Paper 34 is in two parts: The first, by G. H. Jones, describes a wet magnetic separator developed by its author for the treatment of feebly-magnetic minerals. It does its work in a cycle of three stages, with between 10 and 15 cycles/min.: *First*, the magnetic particles are collected from the feed on grooved plates in a magnetic field; *secondly*, these particles are cleaned by a pulsed stream of wash water; *thirdly*, the field strength is diminished while the water velocity is increased, the particles being thus displaced. Feed, slurried to 15% to 25%

solids, is admitted for about 2 sec., the non-magnetics flowing down and out. The feed valve then closes and wash water is admitted for 1½ sec. Two pulses are given to dislodge entrained non-magnetics, which can if necessary be recycled. A quick displacing flush of water under pressure (30 lb. per sq. in.) is then given with the electric current switched off. Each product is separately delivered. The underlying theory is presented by the author with figures of the treatment of a *minus* 35-μ thickener underflow which assayed 0·86% WO_3 and from which an 89% recovery was made with a grade of 8·14% WO_3. Similar results were given from the *minus* 25-μ thickener overflow.

The second part of Paper 34, by W. J. D. Stone, describes experiments made with the Jones separator. Garnet at *minus* 28 *plus* 65 mesh was cleanly separated from quartz. A feed of quartz, quartz-pyrite, and grains stained with iron oxide was treated both by this machine and by high-intensity separation, the Jones separator giving somewhat better results. Other separations were of iron-bearing minerals from granite; zeolite from basalt and magnetite; iron-stained material from weathered graphite; apatite from ilmenite and magnetite; biotite from kyanite; quartz from hematite, etc. Effective separations were reported in these cases, both on coarse (*plus* 100 mesh) and fine feeds and in some cases on material not usually considered suitable for magnetic treatment.

In the next paper (35), by J. de Robert and L. Casnabet, a new wet separator for treating the ores of Lorraine, which can be cut at a magnetization coefficient of 20×10^{-6} c.g.s.m. is described. The present procedure requires costly drying before the use of dry-working roll separators. The new apparatus, devised by R. Forrer, develops a "magnetic corridor" in which paramagnetic particles are retained while those which are diamagnetic are either centrifuged out or flushed away with water. The average ore grade is about 30% Fe, the iron occurring mainly in limonitic oolites between 100 μ and 500 μ in size and assaying 50% Fe. Detrital quartz in the same size range and a ferruginous calcite, which cements the deposit, are the main gangue minerals. A series of poles is set to form the sides of the magnetic corridor, those on the one side being spaced between those on the other. Centrifugal force is impressed on the falling pulp by the curved pole pieces and secondary water displaces the tailings to the non-attracting side of the falling stream. Substantial feed rate is possible and electric power is below 1 kW./ton. The difficulties still existing in the laboratory appliance are surmountable.

R. E. Barthelemy and R. G. Mora in Paper 36 review the subject of electric high tension as applied to mineral beneficiation and deal with the principles at work and their application in specific operations—titaniferous beach sand, chromite, iron ores, and tungsten minerals.

Studies on the interplay between mineral conductivity and air humidity in electrostatic separation are reported in Paper 37 by Professor I. A. Kakovsky and V. I. Revnivtzev. For low-conductivity (dielectric) minerals the basic factor is the surface conductivity, mainly determined by the sorbed water. Hence pairs of minerals can develop four types of difference. (*a*) They can differ in dry air but coincide in damp air; (*b*) they can reverse (*a*); (*c*) conductivities can differ with changes in humidity; (*d*) conductivities are similar at all humidities. With type (*a*) mineral and air should be dry, with the second moist. Case (*c*) presents no difficulties. Case (*d*) requires conditioning of the surfaces with reagents which confer differences between their hydrophobicities sufficient for electrostatic methods to work. Organic heteropolar adsorbed or chemically-attached reagents specific to one of the pair of minerals provide one approach. Inorganic resurfacing films of high conductivity or special affinity for water give another. The situation has much in common with conditioning for flotation. Such pretreatment does not markedly affect the electrical properties of high-conductivity minerals.

Paper 38, the last of this group, by Dr. A. A. Linari-Linholm, describes an optical method of separating diamonds from opaque gangue, based on the refractive quality of the gemstone. An endless belt carries the feed through a beam of light. Flashes from diamond surfaces are detected electronically and the gem is mechanically deflected from the passing stream. The method does not work with very dark or black diamonds. The laboratory model is described and details of test results are given on a variety of feeds. The apparatus was developed to improve sampling control of raw feed and gives very high recovery on *plus* $\frac{3}{16}$-in. material. The author considers it might be developed for commercial recovery.

Session VII—Chemical Processing

(*Papers 40–44*)

Processing was the subject of the next session, at which Professor R. T. Hukki presided. Dr. J. M. Fletcher introduced the papers.

In Paper 40 Professor F. A. Forward, H. Veltman, and A. Vizsolyi describe a method of producing silver-free lead of high purity from sulphide ores in the following stages :—

(*a*) Acid pressure leach to oxidize Pb S to $PbSO_4$.

(*b*) Leaching in aqueous solution of alkaline amines at room temperature to form soluble Pb-amine complexes.

(*c*) Carbonation of the complex solutions with CO_2 to precipitate pure basic lead carbonate.

(*d*) Reduction of this carbonate with carbon to yield high-purity lead.

(*e*) Regeneration of amine leach solution with CaO at room temperature, the $CaSO_4 . 2H_2O$ being discarded.

Using diethylene triamine, a concentration of Pb of 650 g./l. can be reached. Associated Cu, Ni, Co, Zn, and Cd are not precipitated by CO_2, the lead purity reaching 99·99+. The amine complexes are formed at 20° C. and $PbCO_3 . Pb(OH)_2$ is precipitated by CO_2 at the same temperature. Silver content is 0·000005%. Only the reduction of carbonate to metal requires heat.

N. N. Maslenitsky and P. M. Perlov in Paper 41 describe the alkali-leach treatment of low-grade scheelite and wolframite concentrates. Using temperatures up to 225° C. recoveries of over 95% have been achieved in tests. The mechanism of interaction between Na_2CO_3 and $CaWO_4$ has been studied. A method for separating tungsten from molybdenum has been developed which gives 98%, or higher, extraction of the Mo.

Paper 42 by Dr. A. R. Burkin describes the pressure leaching of some silicate minerals in alkali solutions. Quartz, beryl, and zircon are attacked at 300° C. while baddeleyite remains unaffected. The rate-controlling step is chemical, probably due to the breaking away of the silicate or zirconate ion from the crystal lattice.

The staff of the Research and Development Branch of the South Australian Department of Mines in Paper 43 review the mineralogy of Australian uranium deposits and indicate developments in their treatment. Beneficiation before leaching or preconcentration in suitable cases is studied. At United Uranium, N.L., jigs and tables produce pitchblende concentrates from a *minus* 6-mesh feed with low overall recovery, tailings being stockpiled. A summary of developments at Radium Hill is given, treatment including flotation with fatty acids. Similar flotation has been proved possible on the laboratory scale for the adjacent brannerite at Crocker Well. Recovery of uranium from ores and concentrates is on conventional lines. With the exception of the Rum Jungle plant, which uses thickening and filtration to separate solids from liquids, counter-current decantation is practised.

The use of " calcic pre-concentration " in the treatment of uranium ores in full-scale production is described in Paper 44 by R. Bodu. The calcic, or lime, uranate process starts with sulphuric acid leaching and is followed by precipitation with lime in two stages. At pH 2·7 many impurities are removed. The pH is then raised to 6·5–7·0, further precipitation yielding a cake containing 15% to 20% uranium. The accompanying gypsum and hydroxides are then separated from the cake in either an alkaline or an acid process. Flow-sheets, data, and operating details are given.

Session VIII—Process Study

(*Papers 39, 45–47*)

The second day's proceedings closed with Session VIII, at which Dr. J. Convey took the chair, the papers being introduced by Professor F. A. Forward.

The first paper (39), by W. Hellmund, explores the possibilities of fluidized bed roasting for removal of carbon dioxide. The reduction of finely-divided siderite in a shaft furnace is troublesome and leads to inadequate development of the magnetic properties depended on for subsequent separation. The problem of the *minus* 5-mm. sizes has been tackled in many ways without a fully satisfactory solution. A laboratory-scale fluidized-bed furnace was developed and used on (1) de-slimed fines in the range $1·75 > 1$ mm. and (2) thickened sludge of 80% *minus* 60 μ. Carbonates were respectively 79·6% and 61·9% of the feed. The tests to this stage have proved the suitability of fluidized-bed roasting for Siegerland siderite, but several problems await elucidation in the larger furnace now being planned.

The other three papers in Group VIII describe process study in connexion with ore

beneficiation. Paper 45, by G. V. Subramanya and P. I. A. Narayanan, presents the results of studies of 30 low-grade manganese ores, groups them into four types, and suggests the treatment needed for their upgrading. Group (1) has for its gangue minerals quartz, apatite, and other light gangue minerals, which are removable by gravity treatment, magnetic separation, or straight flotation. Those of Group (2) are ferruginous and call for reduction roasting followed by magnetic separation. Ores of Group (3) carry garnet, which is separable by electrostatic treatment or flotation under favourable conditions. Group (4) includes complex ores, which contain phosphorus and need complicated treatment. The ferruginous ores, which are fortunately low in phosphorus, constitute the bulk of the low-grade manganese occurrences in the Indian States where this problem arises. They respond to a low-temperature reducing roast (400 C. to 600 C.), using producer gas, coke-oven gas, or the exit gas from a ferro-manganese plant. From 6,000 cu. ft. to 14,700 cu. ft. per ton treated is the calculated requirement. Flow-sheets incorporating reduction roasting and wet magnetic separation have been developed.

The next paper (46), by F. B. Michell, discusses the application of flotation to the up-grading of gravity concentrates of cassiterite. Since it is important to produce this gravity concentrate at as large a particle size as possible, in order to avoid loss of tin and wolfram, the "fines" which in normal flotation help to stabilize the froth are not available. Here agglomeration flotation on shaking tables is useful, particles up to 2·5 mm. in size being successfully captured in one plant. The penalties imposed by smelters on tin concentrates are about 2s. for each 0·1% of arsenic above a free limit of 0·2% and a general penalty of 2s. for each 0·1% alone or mixed for copper, lead, bismuth, antimony, and zinc. These, as sulphides, are best removed in an acid circuit (pH 3·5 to 5·0). Loss of tin in this sulphide froth is related to pH value. Iron salts are detrimental, ferric sulphate inhibiting the flotation of arsenopyrite. Oxidized arsenopyrite is, however, activated by ferric or copper sulphate. Hematite, by slime-coating arsenopyrite, is a depressant at a neutral pH, being produced by attrition in the flotation cell. In the author's view flotation is preferable to roasting in up-grading treatment.

Paper 47, by Drs. M. G. Fleming and A. J. Robinson, describes and gives details of the tests made in developing a small pilot plant for floating a high-grade apatite (*plus* 90% B.P.L.) from a very fine-grained and complex earth. Starting with the fundamental laboratory tests the investigation is traced through a specially-designed 25 lb./h. miniature flotation unit in London, to a full-scale pilot plant in Uganda. In the final process a feed carrying 15% to 20% moisture is slurried, deslimed, and given wet magnetic separation. To meet the specifications required by fertilizer manufacturers wet grinding next takes the residual material to 80% *minus* 300 mesh and 99½% *minus* 150 mesh, slimes having been discarded and magnetics stockpiled. Flotation takes 45 min. in one rougher, one scavenger, and three cleaner circuits. Caustic soda is used to produce a pH of 9·1 and sodium oleate is the collector. Desliming in hydrocyclones uses 7·4 tons of water per ton of ore and up to 74% of this can be reclaimed from the final slime if sulphuric acid is used as a deflocculating agent.

Session IX—Control and Testing

(*Papers 48–52*)

The five papers in the final session, at which the author, later followed by Mr. J. E. Denyer, presided, deal with control systems and laboratory testing methods. They were introduced by Dr. A. J. Robinson.

Paper 48, by M. J. Cahalan and R. Wolski, discusses the aims of process control and its development in a mineral-processing plant. Some of the techniques described are not yet in commercial use although the necessary equipment exists. The main objective in extensive instrumentation is to increase efficiency and thus to justify the high capital expenditure by maintaining optimum throughput, yield, and quality. The measuring elements transmit their signals pneumatically or electrically to suitably-centralized panels equipped with receiving instruments. On these are set the control levels and from them control signals are sent back to operate the regulating elements. This can be combined with continuous automatic logging which prints out measured plant data and generally monitors the work. After noting that automation is still in its infancy the current possibilities are surveyed.

Crushing can be so interlocked as to give automatic start-up and shut-down. Signals in the system would measure levels of ore in bins, load on crushing machines, conveyor loading, and variance from normal working.

Gamma-ray switches and " sensing " devices which give an alarm when flow is interrupted or a hopper is blocked are available and all would be visible as a diagrammatic presentation on the control board. Control of product size is not yet automated, but much of the manual labour now used can be replaced by automatic size-analysis, etc. In the grinding circuit impressive savings have been shown by accurate monitoring of noise levels; by a gamma-ray density gauge on pulp; by recording classifier returns and integrating these with new feed automatically; by temperature controls on heavily-loaded mill bearings. These are single-loop operations, but a new device called an optimizer puts them automatically into a combined integration. Classification now adds the gamma ray to the bubble pipe. Vacuum at the vortex of the hydrocyclone is well established.

Flotation involves so many variables that any choice of parameters is difficult. Pulp density control is simple; froth texture or quality relies on human skill and is not yet definable in the sort of language spoken by an automatic control mechanism. The flowmeter is practicable but automatic analysis of reagent concentration and change is not yet out of the laboratory stage, sample preparation being one of the delaying factors. Fluorescence spectroscopy, which bombards a sample with X-rays and thus discloses the metal content quantitatively, is progressing but can at this stage only report on the uppermost few thousandths of an inch of the sample it scans.

Dense-media plants are now well automated but density control is still vulnerable to clogging of the sampling lines. Tabling and jigging still lag. Magnetic and electrostatic systems are fairly straightforward as regards process control. Filtration has turbidity monitors but cake thickness is a candidate for automation, together with cake moisture. In thickening, rate of change is slow and so therefore is correction. Here integration with the rest of the plant seems to be the next step. Density check on the underflow is possible, coupled with variation of rate of slurry withdrawal. In pulp pumping variable-speed drives can be automatically operated to smooth out delivery rates. The paper gives a brief glance at automation in leaching and ends by emphasizing the big savings which ensue on wisely planned, worked, and maintained process control instruments.

In Paper 49 M. Digre studies the relationship between concentrate grade, recovery, and ore grade as factors in assessing the relative merits of alternative separating processes in a two-product operation. Study of a multi-product system uses an appropriate expansion of the basic equation developed in the paper. For reliable separation-factor analysis the composition of the ore must be known, together with its separating characteristics in relation to grain composition and size.

Statistical analysis of some variables observed in a series of batch flotation tests is applied in Paper 50, by P. Raffinot. This showed the test itself to introduce the error and led to improved design of the cell used.

W. H. Andrews, in Paper 51, describes assessment of results obtained in flotation tests made under controlled laboratory conditions. These led to improved testing technique, to linear assessment of results, and to consistently reproducible test results in the laboratory flotation of lead and zinc sulphides. Tests made by independent operators and over a period of months have become comparable.

Finally, in Paper 52, L. D. Muller describes various techniques and apparatus used in the mineralogical laboratory as aids to ore treatment study. These include a heavy-liquid diffusion separator, by means of which the minerals settling into layers in a column are recovered separately. The micro-panner is a miniature adaptation of the super-panner which can be used on a microscope stage. The micro-volumenometer provides a precise displacement method of finding the specific gravity of as little as 20 mg. to 30 mg. of material by measuring the volume of liquid displaced into a precision-bored capillary tube. A few grains, hand-picked under the microscope, can thus be tested. The picker belt is designed to ease the strain of sorting small grains under the microscope by installing a miniature belt-conveyor on its stage on to which a narrow band of grains is fed. Grains are removed by suction through a narrow-bore glass tube. The final apparatus described is a rotary sampler which splits up to 500 grams. of particles into 20 fractions with a precision superior to that of the micro-riffle.

Conclusion

During the Congress a representative display of mill items and literature was maintained by leading manufacturers, whose technical representatives were kept busy. The machinery on view was limited for the

most part to static scale models, but in some cases the power available, etc., allowed a measure of mobility. Classification, comminution, thickening, conveying, drying, magnetic separation, flotation, dust handling, dense-media separation, chemical processing, laboratory equipment, pumping, process control, roasting, screening, sorting, thickening, filtration, and washing were all represented. The chief items in this exhibition were given in a short guide published in the March issue of the MAGAZINE.

After the labours of the week the final social occasion was a dinner dance at Grosvenor House. This was so well attended that it was well most milling men were expert in closed-circuit control as the gay international pattern spun to tunes and rhythms, old and new. On Sunday the various coach tours left for Britain's rather limited selection of mine-fields. On Monday, Tuesday, and the closing day, Wednesday, tours centred on London visited some large research laboratories and manufacturing centres.

Writing immediately after the event the author's first reaction is a mixture of relief that the mental exhaustion inevitable in following the considerable programme closely now ends and of wonder at the tremendous progress from Congress to Congress, so important with the world's rising demands for minerals. Many of the new ideas now coming forward may yet fall by the industrial wayside, but enough are already at work to have proved that the work of mineral processing is being revolutionized. New methods of comminution, closer automatic control, and revival and extension of gravity treatment with its " new look " are penetrating our plants. It is obvious to men who work at the consulting level that all this must bring substantial changes in its wake. Some mill men among the members expressed concern at the dominant position given to research papers and their discussion. They would like more practical material to be put forward. Probably the same sort of thing was said in Camborne when Trevithick's first steam carriage trundled up to the Beacon.

To conclude with a flash of the obvious—any symposium is what its contributors make it. If, therefore, in the meetings now being planned for holding in France, the United States, Russia, Germany, and elsewhere during the next decade there are papers or discussions on trouble-shooting, mill economics, flow-sheet remodelling, and process " gimmickry " it will be because practical men have squeezed into their busy days the time to write them.

Modern Trends in Plant and Mining Instrumentation

A review appropriate to a recent London exhibition.[1]

Andrew L. Forrester

Recent trends in the use of instruments in plant and mining operations are simplification of servicing, increased reliability, and lower cost price by the application of certain building-block methods. Other developments are increased standardization of instrument components and of auxiliaries such as record charts and pens. The impact of electronics is rapidly increasing and the wider use of " intrinsic safe " instruments for certain underground applications is noticeable.

So far as intrinsically-safe instruments and gadgets used in coal mines are concerned these are designed to make the best use of known methods and to comply with the existing regulations. A plate identifies these designs as having been tested and certified by the Authority (Ministry of Power). It will be evident, but is perhaps not always realized, that where a single component of a system must be intrinsically safe underground all other parts associated must also contain only approved items. A definite ruling is that a contact maker used for signalling apparatus, etc., must be so constructed as to prevent accidental closing of an electric or electronic

[1] Instruments, Electronics, and Automation Exhibition.

circuit. The Chief Inspector of Mines can grant exception from stringent regulations. "To fail safe" is, however, the basis for any instrument system in mines whether underground or on surface. For example, a current failure must not close a solenoid-operated or motorized control valve inserted into the cooling water inflow to water jackets of air-compressors or diesel engines. The valve must open when this trouble arises and an alarm should be sounded at the same time. Similarly, a hoist or conveyor must be stopped in case of failure of compressed air. A gate must be locked in a safe position if, for example, a hydraulic thrustor or its controlling gadget breaks down. The experienced designer of automatic control systems will see to it that accidents are avoided if a control instrument or the regulating unit fails or if power supply stops.

An example is the range of equipment designed for use in mines made by Westinghouse Brake and Signal Co., Ltd. Interlocking of points and signals to ensure safe operation of traffic above and below ground in all directions can be applied and such control can be localized or centralized, may be manual or fully automatic, or may be semi-automatic. Where cost considerations apply partial interlocked control can be provided for and safety measures taken to ensure smooth traffic operation. Locomotive haulage traffic signalling underground uses such advanced techniques as driver-operated

Fig. 1.

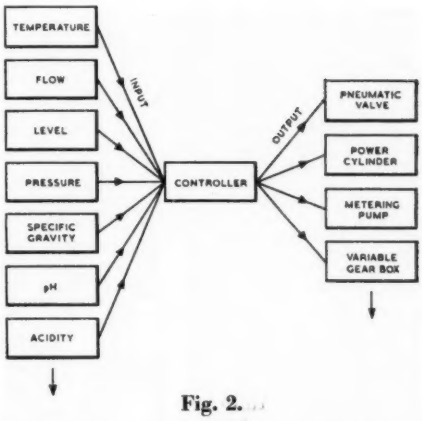


Fig. 2.

systems of colour-light signals interlocked with each other and with the track points over which the train passes. Thus train movement from a number of loading stations to a shaft can be made absolutely reliable.

Automatic Control Dominates

From the indicating phase, *via* the recording phase, the automatic control phase of instrumentation has been reached. The latter is now widely applied to many continuous plant operations and occurrences—such as, conveying, pumping, and regulation of mine ventilation. In Fig. 1 is seen the manufacture of a graphic control instrument panel, reproduced by the courtesy of the Du Pont Company (U.K.), Ltd. For batch processing modern push-button control is used for many types of weighing, mixing, and storage machines. Fig. 2 illustrates in diagram form a few applications of automatic control. What are called "process variables" are measured on the input side of a control system while on the output side are produced reactions from regulating units like control valves, power cylinders, electric contactors, motors, and variable gears.

Telemetering.—Not only have instrument types and designs changed in recent years but also instrument location. In mining the use of telemetering systems is of the utmost importance, whereby measurement underground or at some distant point on the surface is transmitted either pneumatically or by means of cable to a central supervisory or control instrument panel. The use of electrical or electronic instruments allows covering of many miles distance between a motor-driven unit and the engineer's office.

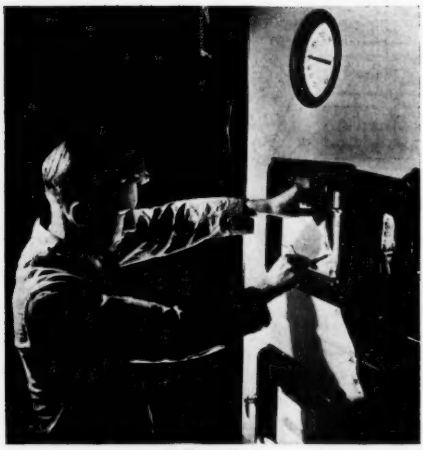


Fig. 3.

Recording Instruments Prevail

A trend which has come to the forefront in recent years is the replacement of purely indicating instruments by recorders as shown in Fig. 3, where the operator is seen removing the day's record from an Arkon recorder (Walker, Crossweller, and Co., Ltd.). A chart record is irrefutable evidence of what has happened during a certain period of plant operation and allows the engineer better supervision of events than a mere indicating instrument would provide. Instruments are now available described as "operation recorders" in a variety of designs with either circular or strip charts. For example, small circular chart recorders are made in a mechanical self-contained version and as an electrical recorder as shown in Fig. 4 by Servis Recorder Co., Ltd. A stylus writes on a waxpaper chart and records idle times and times of operation of, say, a road vehicle, a fork-lift truck, conveyor, lift, screening feeder, and similar matters. A typical operation recorder is shown in Fig. 5 by Evershed and Vignoles, Ltd. These are available with one or two pens or as multi-pen instruments as in the type illustrated. The value of the latter is that the correlation between several movements of machines or within a plant system can be seen at a glance, such as the operation of a conveying system or machines on a screening and mixing plant. The working principle of these instruments is simple: Each pen arm is connected to a small electro-magnet by means of low-volt cable. A contact at the point of operation, which may be at considerable distance, closes (or opens) at certain times. The latter action will be recorded by the instrument pen, which has been attracted to the paper chart by magnetic force.

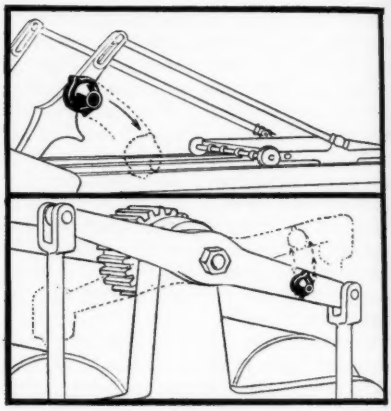


Fig. 4.

Pneumatic Control

Although electronic instruments are developing at an ever-increasing rate there are instances where compressed air is preferable as the power medium for automatic control for various reasons. For example, the larger control valves and air dampers and power cylinders will be actuated by compressed air because electrical operation is both difficult and costly. In such instances the advantages of electrically or electronically operated control systems can still be obtained, but for actual operation of the regulating unit or control element (diaphragm valve, pneumatic or hydraulic power unit, etc.) an "electro-pneumatic converter" is employed. Fig. 6 illustrates such a unit made by Elliott Brothers (London), Ltd., and used to convert an electrical direct-current signal into a proportional air pressure. A moving coil within a pot magnet acts by means of linkage on two ball valves. A constant air pressure supply is transformed into two air outputs, which may be unequal until balance is reached.

Compressor and Engine Protection

A branch of instrumentation for safety which has come into the forefront in recent years is to be seen in those instrument panels which contain means for protecting compressors and oil engines. A number of firms

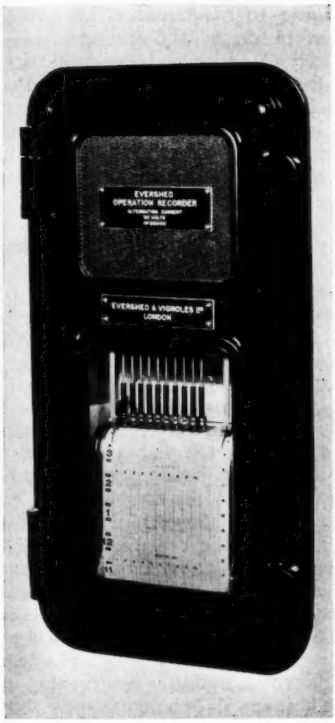
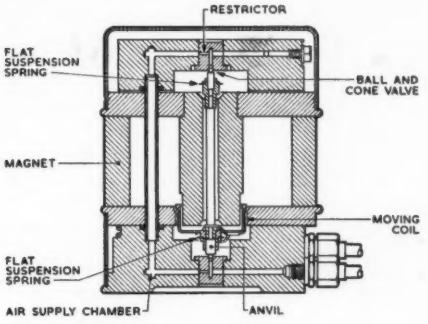


Fig. 5.

have specialized in this type of instrumentation and an example of each application is given. Thus, Teddington Industrial Equipment, Ltd., make compressor and diesel engine protection equipment marketed under the trade mark "Teddington." Their compressor protection instrument panels and devices provide protection for any type of air-compressor against all possible hazards. Inbuilt "fail-to-safety" features comply with the requirements previously mentioned. Vibration resistant, shockproof, and quickly responsive Teddington equipment is to be found in many mines both above and below ground. Reciprocating compressors can be left to run without supervision for long periods as can oil engines. Employing intrinsically safe circuits, the equipment shuts down a compressor or diesel engine automatically before trouble can start. Audible and visual indication and alarm locates the fault. Fig. 7 shows an instrument panel in a diesel-driven rail car and Fig. 8 a compressor protection panel as used by the N.C.B.

Of interest to users of gas, diesel, and petrol engines is a new safety control introduced by Honeywell Controls, Ltd., which provides positive protection against the pressure variable dropping below, or the temperature variable exceeding, the safe limit. The controller instantly stops or idles the engine or actuates an alarm circuit and has been designed to withstand severe vibration so that pressure and temperature settings cannot drift, with consequent false shut-down. To actuate the final engine control element or alarm circuit each system has an independent changeover micro-switch which is itself unaffected by vibration. Temperature and



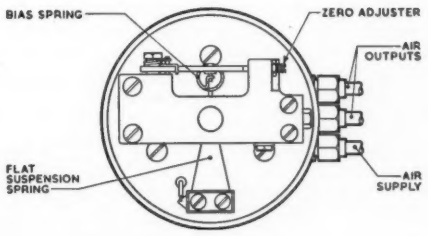


Fig. 6.

pressure scales, visible through windows in the front of the case, are located with setting adjustment spindles inside the case for protection against tampering. They are conveniently reached on removing the case front.

The temperature measuring system has an exclusive fail-safe feature so that in the event of damage to the sensing elements the controller responds as for excessive temperature and stops the engine. Hand control is also provided for and an external knob, located on the front of the instrument, allows manual start and stop of the pressure mechanism.

(To be concluded.)

Ore-Dressing Notes

(12) *Control.*

Evolutionary Operation

The generally used methods of establishing optimum conditions in plant have for a long time been based on a reconciliation between the results of batch and pilot tests made in terms of a designed experiment. The findings are then transferred to the fully operating process. As a drastic means of action when something is seriously amiss the designed experiment, checked and then transferred, has its place, but when a complex process is only a little below optimum performance the remedy may be worse than the disease. G. E. P. Box has defined " evolutionary operation " in part as " a method of process operation which has a ' built-in ' procedure to increase productivity " (*Applied Statistics*, 1957). Discussing the subject and its use by American Cyanamid, T. L. Koehler, in a paper in 1958, considered the use of methods in line with this definition in raising plant efficiency. Taking a hint from biology, which holds that the two basic elements in natural evolution are variation and selection, resulting in progress linked with " survival of the fittest," the variations introduced to a manufacturing process are brought in on a trial-and-error basis and subjected to appropriate scientific scrutiny. Thus the optimum operating conditions are reached gradually, voluntary changes being made in two or three control variables only. Box's paper recognises an element in industrial production of which the mineral dresser has long been keenly aware. " The effects of the deliberate changes in the variables will usually be masked by large errors customarily found on the full scale. However, since production will continue anyway, a cycle of variants which does not significantly affect production can be run almost indefinitely, and because of constant repetition the effect of small changes can be detected."

Selection follows the study of the effects of variation and in Koehler's paper is made after these effects have been posted on an " information board " and studied over an adequate period by the process supervisor. Such a board is shown in Fig. 1, on which, in each graph, the central figures (530 and 4·1) represent standard operation and the four correct sets the variations and the process response. From study of this several possible modifications emerge. These may include change of pattern so that one corner is made the standard, lengthening of the graphed intervals changing one or both

INFORMATION BOARD

Phase I — Cycle 7

Response	Yield	% Impurity
Requirement	Maximum	Minimum
Running Averages	Conc (%) 22: 525 490 / 21: 530 / 20: 540 531 — 82 84 86 Temperature (°C)	Conc (%) 22: 3·8 4·7 / 21: 4·1 / 20: 3·8 4·4 — 82 84 86 Temperature (°C)
95% Error Limits	± 20	± 20
Effects with 95% Error Limits — Temp	− 11·0 ± 10	0·38 ± 0·29
Conc	− 14·0 ± 10	0·08 ± 0·29
C X T	6·5 ± 10	0·08 ± 0·29
Change in Mean	6·8 ± 18	0·06 ± 0·52
Standard Deviation	25·9	0·75

Fig. 1.

variables. A start with a two-variable programme can be expanded to three-variable study as new insight into the control mechanism is gained. As an individual factor approaches its optimum value a new one should take its place for detailed scrutiny and this calls for a supply of new ideas and suggestions from those in touch with the process at suitable points. In the example described chemical engineering personnel are recommended as an " evolutionary operation committee." To quote : " Where there is no feed back of ideas to research, when little thought is given to the selection of new variables, the life blood of evolutionary operation is cut off." Mill operators who have been privileged to work in planned and integrated co-operation with skilled research and consulting levels on the one side and key operators, statisticians and cost evaluators on the other, probably recognize the value of this approach to process control and have seen difficulties smoothed, mistakes permanently rectified, and important running economies secured by its use. The writer of this note has repeatedly seen effects of this sort brought about by properly-organized teamwork. The very small operator may not be able to organize the intensive research pattern called for if such a tuning-up of his flow-sheet is to be worthwhile, but he need not be small-minded despite his limited resources. The scientific crumbs from the more richly endowed tables can be gathered and used.

(13) *Germanium.*

Recovery at Kipushi

The mineral renierite [Cu, Ge, Fe, Zn, $Ga)_4$ (S, $As)_4$] present in finely-disseminated form in the copper and zinc sulphides in the Kipushi ore is usually unrecoverable by gravity, flotation, or magnetic treatment, save in local concentrations. It floats readily in the roughing stage of copper sulphide recovery. Pilot-scale tests having shown that under favourable conditions magnetic treatment to segregate a germanium-rich fraction was possible, an installation based on the use of discontinuous Ferro Filters was installed. These filters receive copper concentrates from the first stage of copper flotation (Fig. 2), in which the original concentration of germanium (220 parts/million) has risen to well over 6000 parts/million in a pulp assaying over 36% Cu. The filtration cycle operates in three stages on each of

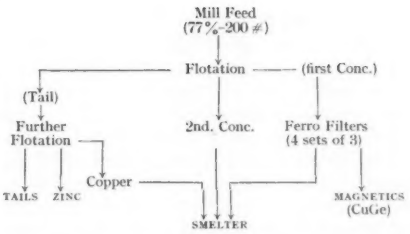


Fig. 2.—Kipushi Ferro-Filter Flow-Sheet

three sets of filters, the fourth set being idle for cleaning. The filters of each set are fixed to a disc which completes one revolution every 135 seconds. During the first step the primary copper concentrate is fed to the filter for 90 seconds, magnetic force being generated by a 16-amp. current at 110 volts on each filter. The non-magnetic " filtrate " flows on while a CuFe magnetic concentrate assaying 0·919% Ge is retained. Next, the filter is flushed with water for 15 seconds, any displaced material going back to the flotation circuit (not shown in Fig. 2). Finally the electric current to the filters is discontinued and flushing water is used for 30 seconds to discharge the magnetic concentrate. The horizontal rotating disc is fed from above and discharged into a circular tub provided with radial partitions suiting the loading, washing, and discharge portions of the cycle. Some adjustment of the duration of cleaning and discharge is possible. The resulting concentrate is smelted in an electric furnace, germanium being volatilized at a concentration in the recovered fume of from 4% to 9% Ge.

(14) *Comminution.*

Pebble Milling

With increasing interest in the use of autogenous grinding media the problem of maintaining an optimum tonnage of crushing bodies must receive closer attention than is needed in ball-milling, where a daily top-up is normally sufficient. Using the Oxford English Dictionary part-definition of " autogenous " as " self-produced," and from this defining autogenous grinding as that in which the grinding media acting on the ore come from the ore itself, it is probable that the only substantial differentiation of the mobile solids in the mill's crop load resides

in the size analysis of the participating particles. From this starting point it is interesting to speculate as to the percentage of these solids which makes no contribution to the overall consumption of power. From all that is known of grinding action in the ball-mill there should be a fruitful field for research on this matter. What is the smallest crushing pebble that can usefully exercise (*a*) impact and (*b*) abrasion on the average particle? What size is the average particle? What is the undersize cut-off particle which may be presumed to recirculate in a closed mill-classifier system without substantial further reduction? What role is played by the worn-down pebbles after they are too light (and small) to crush effectively while they are still large enough to make for an open texture in the crop load? What would be the effect of a two-stage process in which only large pebbles entered with the rod-mill discharge to the primary fine grinding, in which provision was made for pebble discharge below some specified size—for example, by the use of large-aperture retaining grids which passed 3-in. material? Is there any difference between the wearing rate of a large pebble in a mill speeded up to impact action and of the same pebble grinding at a largely abrading speed? Does pebble consumption vary with the assay grade of the pebbles themselves, as one would expect when it is recalled that grindability varies with assay grade? Finally, how is a string of questions like this to be modified in the case of the Rand bankets, where barren quartz is picked from the run-of-mine ore to serve as crushing bodies—a variation on autogeneity? The writer of this note finds it a useful, albeit humbling, exercise to formulate queries along these lines when studying a subject which is currently of such live interest in milling circles. In addition to such contributions as the International Mineral Processing Congress papers by D. Weston (on Aerofall mills) and P. Westerlund (on autogeny in a vertical mill) a good deal is being written on cascade wet milling (the new Hardinge approach) and on the relative technical and cost merits of steel and pebble loads.

One's general impression at this time is that we may expect a move away from grinding with metal and toward steadily-increased use of autogeny, but that the rod-mill is likely to hold its own for a long time to come as the size control for new feed to the wet-grinding mills which complete the job. If this reading of the signs of the times is valid it carries with it the endorsing factor that experience has shown the change to be justified. As to cost there is always an advantage in having the grinding media provided free and even in benefiting as these media grind down into profitable mill feed. Iron and steel balls wear at the rate of up to 2 lb. per ton of ore crushed—*i.e.*, the best part of a shilling per ton for something which at best is useless in its abraded state. This gives the metallurgist a useful cost-per-ton item to offset against lowered efficiency, higher tailings, or reduced milling capacity. How much of the advance in the use of pebble grinding is due to this figure and how much to other factors? It does not follow that there is in practice any falling off in grades or throughput. On the contrary an increasing amount of test work points in the other direction. In passing, however, it must be remembered that the main application of pebble milling is with gold ores. Here we are dealing with something of a "shot-gun wedding" between costs and technique, since gold stays at its pre-war price, costs have risen steeply, and the modern world of banking seems to be increasingly learning to conduct its affairs with a shrinking gold backing. This adds up to an emphasis on selective mining to maintain a cut-off grade which must be sensitive to these inflationary factors. If nothing else will give way then the mill heads must be richer (or the tailings assay higher, if that will reduced costs).

After reminding oneself that milling is ultimately governed by overall costs even more than by isolated efficiency it is interesting to ponder the questions raised at the beginning of this note. In the two comparative newcomers to full-scale milling—the Aerofall and the Cascade—design has changed radically, but these two systems cannot be compared since the former works dry and the latter wet. The limitations on subsequent treatment of dry grinding are not yet known, despite the successful use of the Aerofall ahead of copper flotation and cyanidation. The cascade principle seems, in our present state of knowledge, less liable to set up new problems of preconditioning for flotation. What, then, is the position for a mill equipped with standard grinding mills which contemplates the use of pebbles in place of balls? Study of the shape of the Aerofall and the Cascade mill suggest that for full development of the possibilities a great deal more needs to be known as to the reasons for these changes of shape. Answers based

on the obvious value of a big diameter and a longer fall to compensate for the lower density of the crushing body do not take us far enough. What happens to the crushing body when it has fallen a few times? What does the new shape do that the traditional pebble-mill cannot do? If we dig into crop-load composition in the pebble-mill, with the wealth of accurate research which has been applied to ball-mill loading, what is likely to happen to the ideal shape of the resulting mill? A trend has started and no doubt these and many more questions are being looked into in specializing laboratories. Mills with plenty of capacity and parallel circuits should be able to take their part in answering some of them. The problem of scale-up from batch *via* pilot operation to full-scale working cannot in our present state of technical knowledge be satisfactorily worked out unless the last part of it is a team job in which large tonnages are treated and products are critically examined, by the metallurgist, the mill manager, and the cost accountant.

Book Reviews

The Petroleum Handbook. Fourth edition. Cloth, large octavo, ix + 678 pages, illustrated. Price 21s. London: Royal Dutch-Shell Group of Companies.

This book has been written by members of the staff of companies of the Royal Dutch-Shell Group. With that authorship in mind the reader expects and surely finds a systematic, authoritative, and lucid treatment of its subject-matter throughout the volume. The editor's part in that co-operation must have been a laborious one; its successful achievement is reflected in the work as a whole, in its clarity of expression, and the good taste displayed in its production.

Following a survey of the petroleum industry of the world and a brief account of the Royal Dutch-Shell Group, chapters are devoted to the technical aspects of petroleum production, manufacture of oil products and petroleum chemicals, storage, transport, and distribution, the applications of oil products and petroleum chemicals, and research. Photographic illustrations are accompanied by many specially-drawn and coloured diagrams of excellent quality. Technically-interested users of petroleum products could find no better introduction to the vast industry of hydrocarbon chemistry and for students of petroleum technology here is a basic industrial textbook obtainable (if not already out of print!) at a very modest price.

The petroleum industry has grown up in an age of scientific research and its rapid and widespread development is the outcome of an early enlistment of scientists to its ranks. In this activity the Royal Dutch-Shell Group has always been outstanding. For producing the 4th edition of their Handbook the publishers are to be thanked and congratulated for making available so handsome a volume.

W. E. Gooday.

Netherlands Oil Equipment Manufacturers (N.O.E.M.): Catalogue 1960. Cloth, folio, xxxii + 296 pp., illustrated. The Hague: N.O.E.M.

Some 55 members of N.O.E.M. contribute illustrated particulars concerning field and refinery equipment from wire ropes to generating sets and from catalysts to Christmas tree assemblies. This well-produced catalogue includes 16 pages of N.O.E.M.-DIJKERS' Conversion Tables. It corresponds to the publications issued, each in its respective realm, by other members of the Federation of European Petroleum Equipment Manufacturers.

Quin's Metal Handbook: 1959 Edition. Pocket size, 640 pages. Price 27s. 6d., post free. London: Metal Information Bureau, Ltd.

The 45th edition of this useful handbook has been completely revised and brought up-to-date, a new feature of considerable interest being the inclusion of extracts from the official Soviet Union foreign trade statistics relating to the exports and imports of ferrous and non-ferrous metals for 1957 and 1958. Other new items include a daily weighted average price for electrolytic copper, on a wirebar basis c.i.f. Europe, and approximate average analyses of some representative brands of antimony. In addition the sections covering brands and analyses of copper, tin, lead, and zinc have been considerably enlarged.

As usual, concisely indexed, the new Quin contains a wealth of information covering numerous countries relating to prices, production, consumption, exports, imports, destinations and sources, brands and

stocks of non-ferrous metals, ores, scrap, iron, and steel, ferro-alloys, tinplates, blackplates, galvanized sheets, etc.

Statistical Summary of the Mineral Industry : World Production, Exports and Imports, 1953–1958. Paper Covers, 386 pages. Price 27s. 6d. London : H.M. Stationery Office.

The current edition of the " Statistical Summary " contains the usual production tables for metals and ores, these giving as far as possible the amount of primary metal obtained and showing separately, wherever important, production of secondary metal. Comprehensive sections on coal and petroleum include statistics of the production of and trade in by-products and refinery products. Statistics for all the principal non-metallic minerals are also included.

Perhaps in no other publication is there such a wealth of information on world exports and imports of minerals and metals, including not only the crude material but the chief semi-manufactured products, refinery products, and other derivatives.

Mining Journal Annual Review, 1960 : A record of progress. Paper Covers, quarto, 368 pages, illustrated. Price 21s. London : The Mining Journal.

This annual survey covers as usual progress in mining both from the technical and economic angles. In addition to the study of the position of the various metals, there are authoritative sections dealing with recent developments in mineral exploration, mining, ore treatment, and refining. Finally there is a country by country review of the industry over 1959 and the customary section dealing with the share market and company affairs.

☛ Copies of the books, etc., mentioned under the heading " Book Reviews " can be obtained through the Technical Bookshop of *The Mining Magazine*, 482, Salisbury House, London, E.C.2.

Engineering Log

The mine dust which is generally believed to cause pneumoconiosis is composed of *minus* 5μ material. Above this size dust cannot penetrate to the inner parts of the lung. The National Coal Board now employs more than 400 men underground with a laboratory staff of about 200 microscopists to deal with the airborne dust sampling in mines. The original thermal precipitator has been improved, as have the konimeter, the Owens jet counter, and the cascade impactor. Filters and scanning devices have all been employed in this work, as has metal shadow printing. For this the sample of dust is exposed in high vacuum to bombardment by aluminium atoms and an opaque aluminium film is produced only 0·03μ thick having transparent holes which are correct shadows of the particles. Another method which has been tried uses the absorption and scattering of light by dust, while the Tyndall effect is made the basis of a measurement in German mines. Here, a short light pencil shines through a small chamber containing a sample of the dusty atmosphere and the " scatter " is measured by means of a photometer. Attempts are also being made to weigh the airborne dust. A large volume of air must be sampled before this becomes practicable and the apparatus suitable for doing this work has not yet been completely developed. The technique used in any particular case depends on the nature of the dust, the particular feature of that dust which is to be measured, the conditions of sampling, and whether a few precise measurements shall be made or a number of rough ones.

* * *

A report recently issued by the United States Bureau of Mines [1] describes how a high-speed motion-picture camera and other photographic equipment are being used by the Bureau to gain a clearer understanding of what happens when rock is shattered by explosives. By exposing super-sensitive film at speeds up to 3,200 frames per second the camera can faithfully record blasting phenomena that occur in fractions of a second. When developed and projected at normal speed the film becomes a " slow-motion " picture, enabling viewers to study closely the split-second reactions that took place during blasting. Work of this type has provided valuable information over the past few years, according to the report. For example, it has shown them how rock

[1] BLAIR, B. E " Use of High-Speed Camera in Blasting Studies." *Rep. Inv. U.S. Bur. Min.* 5584.

s moved by the blast; how "stemming" used to confine an explosive charge may either resist, or be dislodged by, the force of an explosion, and how detonation gases escape through broken rock.

* * *

The original concept of Hooke, Newton, and Herschel that the roughnesses in a roughly-ground surface were produced by cutting away during polishing, a process which left a series of fine grooves, was later modified and indeed replaced by Beilby's hypothesis that the depressions in the surface are filled in by materials smeared across it. These, according to his 1921 theory, were considered to be glass-like or amorphous and were given the name of the "Beilby layer." More recent work has modified the original amorphous concept, but the basic idea of a physically distinct layer between the substrate and the true interface still holds, although it has been suggested that surface asperities are melted when abrasive particles rub across such surfaces, the liquid thus formed depositing in and filling the joining depressions. Recent work published in the *Australian Journal of Science*[1] strongly supports the earlier view and suggests that polishing is essentially a cutting process and that the "Beilby layer" does not exist. The new theory is that metallographic polishing occurs primarily by cutting and that abrasive particles act similarly to a planing tool and remove material. Scratches are then produced and the better the polishing the finer are the scratches. The resulting surface is still crystalline although deformed and the magnitude of the deformation decreases with finer and finer polishing. Deformation also decreases rapidly with depth so that almost perfect material is exposed by light etching. To what extent the new theory is valid for polished mineral surfaces is not suggested at this time. Other factors come in when one leaves the characteristic gas-electron bonding of a mineral and enters into the zone of ionic bonding of the substrate based on unit crystal structure of a typical mineral species.

* * *

TPR—thermoplastic recording—was first described in the *Journal of Applied Physics* in December, 1959, after nearly a year's delay. The inventor, W. E. Glenn, has succeeded in combining sight and sound recording with almost instantaneous speed and extreme compactness. The first crude laboratory model works on these lines. An original photograph is taken electronically and copied line by line by a pen writing with a beam of electrons. The point of this electron pen hangs in a vacuum over a reel of plastic ribbon made in three layers. The top layer is magnetized to receive the pen impressions, while the middle layer which can conduct electricity is above the third layer, a stable base. When the electrons fall to the top layer its surface is solid. Immediately after the layer is melted and its electrons are drawn down into the conducting layer below. Wrinkles are thus formed at various depths, depending on the strength with which electrons were ejected by the pen. The ribbon runs on far enough for these wrinkles to reach their full depth and is then frozen so that the wrinkles are fixed. This is a furrowed effect which holds the original picture in a form which can be reproduced in close detail without any chemical treatment. If colour is desired an electronic prism is used and four times the space is required, but as the recording is extremely compact there is plenty of room for this. Indeed a single standard size typewriter ribbon spool would hold the complete 24 volumes of the present edition of the *Encyclopædia Britannica*. The immediate use suggested is for making earth satellites able to record everything going on on the face of the earth in colour and, if such a thing can be imagined, sound. If the field of possibilities opened up by this invention proves commercially practicable it should make a tremendous difference to all our methods of communication.

* * *

At Long Beach California a $30,000,000 programme is under way to prevent land subsidence by means of underground repressurizing. The method is water injection. For a number of years land beneath the city has been sinking. The lowest area is that of Terminal Island, where a naval base and shipyard are located, together with a steam plant owned by Southern California Edison Co. Wilmington oilfield, the nation's second largest, is also part of the territory. Batteries of pumps, driven by motors totalling nearly 10,000 h.p., began work last October. Filtered

[1] SAMUELS, L. E. *Aust. J. Sci.*, June, 21, 1959.

sea water is forced into injection wells drilled into the area which appears most critically affected by the subsidence of the land and engineers are confident they will succeed in preventing further trouble there. The City of Long Beach and the oil producers are co-operating in the scheme. Oxygen-free salt water is pumped under great pressure into, or near to, the rock formations in the fault blocks from which oil is being extracted. The oil is driven ahead towards the wells, while the water fills voids previously occcupied by oil. Pressure underground and oil production at the top are increased simultaneously. Submersible motor-driven pumps, with non-corrosive construction, have been used for this heavy duty. Each has an efficient turbine pump assembly suspended from the well-head and hanging so that motor and pump are both submerged in the well. Stainless steel, plastic-coated steel, and plastic have been used for maximum service life in salt water conditions.[1]

* * *

A new German invention for weighing materials does away with the need for separate scales to weigh differing granular products, such as coal, cement, or iron ore. The new device incorporates a conveyor weight-meter capable of measuring electrically the pressure which the materials exert on the belt. Pressure is converted into electrical terms by suspending one roller station from a leaf spring and varying the inductance of an electrical circuit by the movement of this leaf spring. By this means the variation can be amplified and transmitted as a varying voltage. The device is equipped with a recorder which can, if required, integrate the variant readings so as to supply total weight of the materials carried. The mechanism includes provision for stopping the conveyor, once pre-set volumes of material have been moved, or, alternatively, for giving visual or audible signals. Accuracy is claimed to be within one per cent. for the weighing device on capacities within 20 to 110% of rated values.[2]

* * *

Tube Investments, Ltd., have recently produced in this country an interesting wheel turning machine designed to perform the operation of running down the nuts which fasten the spokes to the rim of a wheel. On this operation depends the tension of the spokes. When it is performed manually it is difficult to obtain stress of sufficient evenness on all spokes to give the true form of a circle to the wheel. Any uneven tension distorts the shape of the rim and can skew the wheel to one side of its correct radial plane. The new machine does the necessary tightening automatically, handling one wheel per minute, and tightening each of its 40 spokes correctly to hold the rim to within 0·03 in. *plus* or *minus* of a perfect circle. The process is controlled by means of rotating magnetic pick-ups. These sense rim deviations and pass on-off signals to the motor-driven socket wrench placed on each spoke. Scanning stops when the majority of the spokes reach a preset tension value and the wrenches disengage, enabling the operator to remove the wheel. When it goes on the machine ready to begin the torquing cycle the wheel, with spokes loosely fitted, is clamped only at the hub. As the wheel is lowered the wrenches are engaged by the spokes. Each wrench assembly is made up of a fractional h.p. motor which drives a hexagonal socket through a reduction gear. The housing of the socket wrench is slotted, as is the wrench, and as these slots are brought into alignment the spoke is enabled to enter the socket. A special two-segment commutator on the drive motor effects the alignment. Cam-operated sequence switches operate the segments so that they move round to the armature gap, whereupon the motor stops and the slots are re-aligned. After the spokes have entered the socket assembly slides forward on the spoke towards the tightening nipple at the rim and the spanner motor is rotated by an impulse from the sequencing circuits to ensure correct engagement. The magnetic scanning arm is lowered over the wheel after the sockets are in place. The truing principle is based on a comparison of the location of each point on the rim against a reference circle and a reference plane.[1]

* * *

It is claimed that a new silent valve virtually eliminates all noise associated with the rapid flow of fluids such as results variously from aeration, cavitation, surging and vibration. The valve is said to be flexible in size

[1] *Power Engineering*, March 1960.
[2] *Mill and Factory*, March, 1960.

[1] *Control Engineering*, April, 1960.

and scope ; it can be supplied for installation in systems having line sizes from one inch to many feet in diameter and which handle a variety of fluids. The valve's heart is a cylindrical elastomer plug with a number of axially-aligned holes serving as flow passages. A tubular housing between two perforated plates contains the plug. One of these plates is actuated hydraulically or mechanically to compress the elastic material inside. As compression takes place the diameter of the flow passages is decreased, and the flow is throttled. The large number of small-diameter flow passages is said to allow energy associated with large pressure drops to be dissipated smoothly within the narrow channels by fluid friction. In this way, it is explained, dynamic under-pressures are virtually removed.[1]

* * *

A new machine for grading sheet metal has been produced by a British company for an American concern which manufactures sheeting lines and equipment designed to handle metal in coil form. The new grading machine is basically designed for use in a complete coil-fed sheeting line of the type used by the canning industry. Advantages over existing machines are several. In those currently used selection is automatic, but pallet supply, positioning, disengaging, and unloading are all manual operations. In the new machine all operations except the removal of loaded pallets are automatic and it is from 12 to 14 ft. shorter than the graders currently available in the U.S.A. The grader is a two-station unit and acts on signals to separate automatically the prime and the reject sheets and to stack them on pallets. It can handle 18 in. by 24 in. to 38 in. by 44 in. sheets at a maximum rate of 175 per minute and it can carry pallet loads up to 9,000 lb. Normal operating speed for the conveyor-belt is about 700 f.p.m., but this is infinitely variable from 100 to 1,200 f.p.m. through a P.I.V. gear. The number of sheets per pallet is preset and pallet positioning, hoisting, lowering, and ejection in the prime sheet stacker are fully automatic. The conveyor is fed from a shear line which crops sheets from the coil-strip. The reject gate is placed at an advance point and the first stacking station is for reject loading. When the pre-set number of prime sheets have been stacked on the station at the end of the machine an electrically-operated trip starts the unloading cycle. The loaded pallet rolls to the end of the ejection conveyor, where it sets off an alarm which rings until the pallet has been removed. Another bell gives notice when the last empty pallet leaves the incoming hopper for positioning, both bells being reinforced by coloured lights on the control panel. Any pile-up of sheets along the conveyors automatically shuts down the line. In addition manual shut-down buttons are provided for partial or total close-down in an emergency. The machine is adjustable to different widths and lengths of sheet. The manufacturers envisage eventual application of the new design to production processes involving aluminium sheeting and electrolytic tinning lines. Trial runs with aluminium sheets have been successful, with no end or surface damage to the material, it is stated.[1]

[1] *Power Engineering*, March, 1960.

News Letters

BRITISH COLUMBIA

May 9.

Cominco.—The consolidated revenue from the sales of all products in 1959 of the Consolidated Mining and Smelting Co. of Canada, Ltd., was $110,084,379, as compared with $103,900,459 in the previous year. After providing for income and mining taxes and depreciation of plants the consolidated net profit was $16,704,310 ; net profit in 1958 was $14,017,883. The higher earnings resulted from a substantial increase in the price of zinc, partly offset by the lower prices of lead and fertilizers. Labour rates and prices of operating supplies again showed an increase but inventories of products and raw materials were essentially unchanged from the end of 1958.

During the year 2,440,396 tons of ore were extracted from the Sullivan mine, as compared with 2,443,884 tons in 1958. Underground development and backfilling continued as required for the present rate of mining which is in line with long-term plans for the optimum extraction of the ore-body. Rock excavation was nearly completed on the 500-ft. extension to the main shaft to open two new levels for production.

The Bluebell mine at Riondel was the source of 251,366 tons of lead-zinc ore, as compared with 255,859 tons in 1958. Shaft sinking to lower levels was in progress at the year-end. Some difficulty was encountered because of subterranean water flows. Extraction from the H B zinc-lead mine at Salmo was 463,504 tons of ore, as compared with 458,213 tons in 1958.

At the Con gold mine at Yellowknife, N.W.T., the mill treated 191,299 tons, as compared with 188,497 tons in 1958. The tonnage consisted of 115,593 tons

[1] *Engineers' Digest*, March, 1960.

grading 0·50 oz. gold per ton from the Con mine and 75,706 tons grading 0·58 oz. from the adjoining Rycon mine.

Production from the phosphate mines in Montana was 372,743 tons, as required by the Trail and Kimberley fertilizer operations. Further additions were made to reserves of phosphate rock.

In the exploration field 20 properties were acquired on option out of 84 examined and company prospectors staked an additional nine properties. Surface development work, including nearly 30,000 ft. of diamond drilling, was carried out on 27 properties and underground development was conducted at three. In New Brunswick, at the Wedge copper prospect, an access road, power supply, and camp facilities were established, and a shaft planned for 1,150 ft. had been sunk 510 ft. at December 31 last. At the Duncan lead-zinc property in the Lardeau area a 990-ft. adit was driven and 1,200 ft. of driving was done on the main ore zone in a programme which is being continued. An adit at the Double Ed copper property near Anyox had reached 1,900 ft. at the year-end with 700 ft. remaining to be driven. Underground exploration of the copper property of Sunro Mines, Ltd., near Victoria, was discontinued after failure to increase ore reserves.

Cominco is awaiting with interest a recommendation as to the route of a proposed railway to connect Great Slave Lake with existing rail lines. The property of Pine Poi Mines, Ltd., on Great Slave Lake, had by 1954 been proved to contain an extensive zinc-lead ore deposit that can be brought into production when suitable transportation facilities are provided.

As to metal markets, Mr. W. S. Kirkpatrick, the company president, states :

" The difficult conditions which prevailed in world lead and zinc markets in 1958 eased somewhat in 1959, particularly in the case of zinc. World inventories of refined lead and zinc in the hands of both consumers and producers declined. In the case of zinc this resulted in price appreciation in all world markets. Lead prices reacted less favourably but at the year-end the statistical position had improved and there was evidence of growing strength."

Principal products of the company during the year were 6,275,275 tons of lead, 4,933,495 tons of zinc, 4,040,055 oz. of gold, 357,679,450 oz. of silver, 12,254 tons of cadmium, 2,534 tons of bismuth, 246 tons of tin, 620,162 tons of solid fertilizer, and 56,046 tons of liquid fertilizer.

New Westminster.—The annual meeting of Pacific Nickel Mines was informed it would not be the policy of the directors to pay a dividend by sacrificing the strong investment portfolio of the company. However, Giant Nickel Mines, in which Pacific Nickel holds a 49% interest, is now operating profitably with anticipation of operating profit of approximately $100,000 monthly. After the company has established adequate working capital it is possible dividends may be paid to Pacific Nickel shareholders from these earnings. Pacific Nickel has made substantial advances to Western Nickel which operated the B.C. Nickel mine near Hope in 1958. Western Nickel has liquidated its assets and possesses approximately $1,000,000 in cash with no liabilities other than to its shareholders.

Giant Mascot Mines expects to receive considerable revenue during 1960 from producing mines in which it has invested. The company holds a 51% interest in Giant Nickel Mines, which is exporting a copper-nickel concentrate to Japan and treating 1,000 tons of ore daily. Developed reserves in the Pride of Emory zone are estimated at 500,000 tons grading 1·30% nickel and some 50,000 tons are now broken or drilled for blasting. The annual meeting was informed that the Sumitomo group is paying a bonus of 7 cents per lb. over the price paid by Sherritt Gordon Mines when concentrate was forwarded to Fort Saskatchewan, Alberta. A saving of $8·00 per ton has also been effected in the freight charges on concentrate. Camp McKinney Gold Mines, in which Giant Mascot holds a 20% interest, has shipped 180 tons of high-grade gold ore to the Trail smelter. Current shipments of 30 tons a day are to be increased to 50 tons daily by the end of May.

Lillooet.—The production of Bralorne Pioneer Mines in the first quarter of 1960 was 30,204 oz. of gold from 62,836 tons of ore averaging 0·48 oz. in gold per ton. The Bralorne Division contributed 21,548 oz. from 38,045 tons grading 0·54 oz. per ton and the Pioneer Division 8,656 oz. from 24,791 tons averaging 0·35 oz. per ton. Although tonnage was well maintained the grade of ore was down owing to clean-up of stopes in the upper levels of the Bralorne mine and salvage from sections of the Pioneer mine. Exploration has succeeded in finding at depth a promising gold-bearing structure between the Bralorne and Pioneer workings. Named the " 32 " vein, the search for such a structure has been a primary objective in the exploration programme since 1959 ; it was incidental to the deep-testing of the 27 vein that the new 32 vein was found. The 32 structure has been intersected in drill holes from the Pioneer 29 level and appears to assay 0·74 oz. per ton across 2·0 ft. Drill intersections from Bralorne's 26 level, some 650 ft. vertically below the Pioneer intersections, are believed to be in the same ore-body although considerably west on strike. Further drilling is being done to effect correlation if possible.

Similkameen.—Granby Mining earned an operating profit of $34,041 in the first quarter of 1960 ; after provision of $85,487 for depreciation and depletion, net loss for the period was $74,794. The present operating level of 1,000 tons daily was achieved late in March and, consequently, the figures do not reflect the increased tonnage.

Osoyoos.—Nighthawk Gold Mines is to proceed with a surface-development programme immediately on its 65-claim group near Hedley. Control of the company was recently acquired by W. R. Wheeler and associates, who purchased 1,699,000 shares for $30,000. Mr. Wheeler was the original staker of the Good Hope claim, key to the Nighthawk group, which quickly yielded a return of the $100,000 paid in cash by Hedley Mascot Gold Mines for the claim from its rich telluride ore-body. Directors of the Nighthawk company will advance further funds for development.

Nelson.—The annual meeting of Reeves MacDonald Mines was informed that if the present operating profit continues to be earned a further disbursement will again be made in December. During recent years the company has paid 12½ cents per share annually. The company president, Mr. Jens Jensen, was unusually optimistic in noting the improvement in metal prices, the decline in premium on the Canadian dollar, and the consummation of a new contract with the Consolidated

Mining and Smelting Co., which effects a saving of $4.00 per ton in transportation cost of concentrate shipments. When Reeves MacDonald commenced production in 1949 ore reserves were estimated between 2,500,000 and 3,000,000 tons. To-day after extraction of 2,826,000 tons the reserves are greater than at commencement.

Fernie.—Shareholders of the Crow's Nest Pass Coal Co. on April 26 approved the granting of an option to the Columbia Iron Mining Co., a wholly-owned subsidiary of United States Steel Corporation, to purchase all the unworked coal properties of the Crow's Nest company in the Fernie area for $10,000,000, or, alternatively, if investigation during the next four years at a cost of not less than $500,000 fails to disclose sufficient coal reserves on the unworked lands, to purchase all the Crow's Nest company's coal properties and facilities for $17,000,000.

EASTERN CANADA

May 20.

Ontario Gold Output.—The output of the gold mines of Ontario for March included 229,457 oz. of gold and 37,202 oz. of silver, valued at $7,646,044, from 807,309 tons of ore milled. The Provincial Department of Mines "Gold Bulletin" for the month states that in the March quarter the 30 producing mines reported milling 2,340,981 tons of ore, containing 678,797 oz. of gold and 99,822 oz. of silver, valued at $22,642,960. In the same period of 1959 the 30 mines reported milling 2,334,973 tons of ore, containing 665,357 oz. of gold and 95,870 oz. of silver worth $22,732,512.

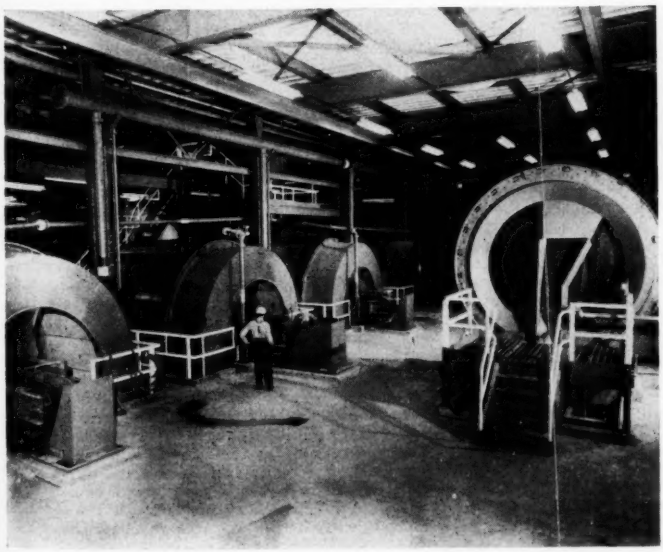
Porcupine.—The operations of Pamour Porcupine Mines during 1959 resulted in a profit of $280,613, as compared with $293,859 in the previous year. In 1959 the mill treated 637,403 tons of ore, metal revenue totalling $2,072,279. Ore reserves at December 31 last are given as 1,607,568 tons averaging 0·105 oz. in gold per ton.

Sudbury.—The interim report of the International Nickel Co. of Canada and its subsidiaries for the three months ended March 31 shows net earnings in terms of U.S. currency of $24,932,000; in the December quarter net earnings were $26,935,000. Deliveries of nickel in all forms during the first quarter of 1960 were at a record high, the report states, the rate of deliveries being greater than the company's production. Its supplies were augmented by nickel acquired in connexion with the reduction of the United States Government's procurement contract obligations.

Manitouwadge.—At the annual meeting of Geco Mines last month shareholders were informed that during the first quarter of 1960 the mill treated 329,089 tons of ore averaging 1·89% copper, 2·71% zinc, and 1·26 oz. silver per ton. The estimated operating profit was $2,063,200 after provision for taxes (other than income) and, after writing off $485,500 for depreciation and deferred development, the estimated net profit was $1,577,700. Since the first of the year the Mining Corporation of Canada, Ltd., loan has been reduced by $3,120,000 and now stands at $960,000.

Quebec.—The Department of Mines has announced that gold shipments from Quebec in 1959 totalled 1,002,024 oz. and those of silver 4,230,097 oz. In the year the copper output was 275,963,058 lb. and that of zinc 94,161,387 lb., while asbestos production totalled 992,331 tons.

In the six months to December 31 last Campbell Chibougamau Mines milled 345,042 tons of ore and recovered 14,327,819 lb. of copper with 17,744 oz. of gold and 107,501 oz. of silver. The operating profit for the period is given as $1,222,920.



Vacuum Filters in Inco's New Mill

It is reported that a series of six boreholes in the main mine have cut a mineralized zone over a strike length of 500 ft. at between 2,700 ft. and 3,500 ft. It is thought that this is a repetition of the main zone and it is to be explored from an internal shaft to be put down to the 3,700-ft. horizon.

The Asbestos Corporation reports net earnings of $3,057,379 for 1959, against $4,143,769 for the previous year, although 3,332,995 tons of ore was milled as compared with 3,207,103 tons. At the end of 1959 reserves totalled 103,871,000 tons, of which 11,470,000 tons were at the King-Beaver, 52,965,000 at the British-Canadian, 25,436,000 at the Normandie, and the balance of 14,000,000 tons at other properties. Reserves at the end of 1958 totalled 111,345,000 tons.

An output of 25,659,720 lb. of copper and 17,091,228 lb. of zinc, with 7,132 oz. of gold, 198,956 oz. of silver, and 53,134 tons of pyrite is reported by Waite Amulet Mines for 1959. The mill treated 311,405 tons of ore and operations resulted in a profit of $3,000,908.

AUSTRALIA

May 20.

Uranium.—The uranium mining industry is earning good money for Australia, the leading producer being Mary Kathleen, in North Queensland In the first quarter of 1960 this mine produced 112,000 short tons of ore for the recovery of 402,000 lb. of uranium oxide, the profit for the period being £A492,946. The mine is among the world's lowest-cost producers and the limits of the ore deposit have not yet been determined.

Two mines in the Northern Territory have become producers of importance. South Alligator Uranium, N.L., in the half year to March 19, milled 2,660 tons of ore of an average grade of 1·03% uranium oxide, recoveries being valued at £A227,326. Profit is now accumulating at the rate of £25,000 per month. The No. 1 level drive is now in high-grade pitchblende and geological and operational data point to the possibility of 1,000 ft. of potential ore-bearing ground ahead of the drive.

United Uranium, N.L., has reported a profit of £A233,960 from eight months' operation, the contract with the U.K. Atomic Energy Authority providing for the sale of uranium oxide to a total value of £A5,000,000, or to a maximum value of £A890,000 a year during each of the years from 1960 to 1964 inclusive.

Although Mary Kathleen has established a water supply in the Corella River dam that is considered equal to about two years' supply for mine and town under normal conditions, provision is to be made to safeguard against failure of the annual wet season over a period. A contract has been let for the construction of a new dam on the East Leichhardt River at a cost of £A250,000. The dam will be a rush job and will be completed before the next wet season at the end of 1960. Length of the dam will be 500 ft., height 78 ft., base width 303 ft., and top width, 12 ft. ; construction will be earth and rockfill. The site is in a gorge half-way between Mount Isa and Mary Kathleen. The new work should assure the mine and town of ample water in the event of the most severe drought.

Gold Mining.—The Western Australian State Government is to give financial support to Great Western Consolidated, N.L., which has been working on the Yilgarn goldfield for eight years with small financial success. The company's mines are the Copperhead at Bullfinch, the Corinthian, and Pilot, in the same locality, the Fraser's line at Southern Cross, and a group of workings south of that centre, all supplying the main mill at the Copperhead mine. The assistance will be in the form of a bank guarantee for £A50,000, the company putting up a similar amount. Since it was established eight years ago, the company has spent more than £A2,000,000 at the several mines and since 1952 it has mined over 3,000,000 tons of ore for the production of 467,000 fine oz. of gold. Great Western Consolidated is one of the State's largest gold-mining companies. The largest ore-bodies are in the Copperhead mine, but grade has been consistently low, slightly above payability.

Oil Search.—Preliminary opinions by the team of geologists from the French Petroleum Institute now in Australia to advise the Commonwealth Government on the prospects of oil discovery are encouraging, but sufficient time has not yet elapsed for weighed opinions based on detailed study of work done and personal observation of the country.

Oil has again been found in the Moturoa district at New Plymouth by New Zealand Oil Refineries, Ltd. Tests are being made to determine if it is present in quantity to make an economic proposition. If tests are satisfactory the well will be the fifth producer that the company has at Moturoa. This discovery will stimulate drilling which is in progress in other parts of New Zealand.

Iron and Steel.—Australian demand for iron and steel is increasing rapidly. While steady expansion has been made by Broken Hill Proprietary at Port Kembla and Newcastle, New South Wales, the major undertaking is the development of the Whyalla works in South Australia into an integrated steel plant. The output by Broken Hill and its subsidiaries was at an increased rate, in March, of steel and tinplate, steel production being 289,300 tons for the month and the yearly rate 3,400,000 tons. In January and February production was 277,567 tons and 267,553 tons for the respective months. Production of tinplate in March was 8,418 tons—an annual rate of 101,000 tons, which greatly exceeds the first annual target of 70,000 tons. To supply the ore requirements the iron-ore occurrence on Koolan Island, Yampi Sound, Western Australia, is being equipped for production and shipping. This ore is friable and will be sintered in the plants being completed at the smelters in New South Wales. Port Kembla has greatly increased coke-oven, blast-furnace, and steel-furnace capacity, but these increases have been quickly overtaken by demand. Koolan Island and Cockatoo Island are important sources of ore supply, but the main source for future requirements is the Eyre Peninsula, in South Australia, where the Iron Monarch and Iron Baron mines are the main suppliers.

There has been considerable prospecting for additional supplies of ore both by Broken Hill Proprietary and by the South Australian Government, while much investigation has been made into the use of low-grade iron ore ; in future there will be much less reliance on the reserves of high-grade ore. Research into the utilization of jaspilite, of which there are very large tonnages in South Australia, is reported to have been successful and these deposits will give a large reserve of potential iron.

The Whyalla plant is being prepared for an output of 400,000 tons of steel per year, but it is expected that the actual output will be in excess of this figure. Methods are said to be in advance of any previously employed in Australia and an oxygen steel-making process will be used. Accommodation is being provided by the erection of 400 houses to meet initial housing requirements.

Bauxite.—The Western Mining Corporation has been carrying out extensive prospecting for bauxite in the Darling Ranges, Western Australia, the State Government having given approval for the export to Japan of up to 1,250,000 tons in the next five years. This is regarded by the State Government as the first step in a long-range bid for the establishment of a £A20,000,000 alumina industry in the State. Three trial shipments, each of 10,000 tons, are to be made to Japanese smelters and if this stage is successful the export of 300,000 tons of ore is possible. Already trial shipments of bauxite have been made to the Bell Bay works of the Australian Aluminium Production Commission in Tasmania and it is believed that the ore has been approved. It is, therefore, probable that Western Australian bauxite may replace importations from Malaya and Indonesia. The work in progress in the Darling Ranges is designed to develop reserves sufficient to warrant the establishment of alumina works in Western Australia.

Tasmanian Iron Ore.—Tasmania has hopes of establishing a State-owned steel industry centred on the possibilities of the Savage River iron-ore deposits in the north-west of the Island. Drilling has been in progress there and some 2,000,000 tons of ore is spoken of. Quality of the ore is to be determined by a trial shipment of 200 tons to be made from Burnie. A decision has not yet been made as to where the ore will be treated, but it is suggested that the work will be done overseas. Early reports have suggested that the Savage River ore is low grade and would need upgrading before smelting. Considerable attention has been given to iron-ore occurrences in Tasmania and it is considered that the Savage River lodes are the most promising of those examined

Tennant Creek.—Peko Mines, at Tennant Creek, is the copper producer of the Northern Territory. At the main mine workings have reached a depth of 1,000 ft. and production of gold-copper ore is about 10,000 tons per month; concentrates assaying approximately 27% copper and 9 dwt. gold have, in the past, been consigned to the Port Kembla smelters in New South Wales, involving about 1,600 miles of transport. The ore reserves are 1,000,000 tons but the tonnage does not warrant the cost of a smelter at the mine. Arrangements have now been made with Japanese smelters for the sale of concentrates and the contract provides for the delivery of 30,000 tons per year. Price and terms are stated to be advantageous to the company, but the price received under the agreement will be world parity and any benefit from improvement in the Australian price will be lost, as well as the assistance of the Copper Bounty. The amount of copper involved in the contract is about 7,400 tons of refined metal per year.

Prospects of establishing a copper smelter on the mine depend upon the development of the Orlando mine, eight miles distant. Diamond drilling and underground work there have proved a lode channel 70 ft. wide to a depth of 380 ft. over a length of 800 ft., while diamond drilling has made intersections at a depth of 580 ft. The lode channel is highly oxidized and leached to below the 420-ft. horizon and residual unoxidized ore carries good copper values. There is room in the dimensions exposed for the presence of important ore-bodies in the primary zone and also in the zone of secondary enrichment. The shaft is being continued from the 420-ft. level to 580 ft. and further diamond drilling is being done to test the lode below the oxidized and leached zone. This intense oxidation and leaching was not present in the Peko Mine itself eight miles to the east. Gold values in cores from diamond drilling at the 420-ft. level and at 570 ft. have given assays of 18 dwt. and 11 dwt. over widths of 10 ft. and 23 ft., but leaching makes results unreliable at present. If the work at greater depth over the next six months established an ore-body, which there is reason to anticipate, there will be a prospect for considering a copper smelter and Tennant Creek may become a copper-producing centre of some importance.

Geology is puzzling and the whole field is definitely the most difficult in the Commonwealth. Ore-shoots have ended at shallow depths and, although certain major factors are associated with all ore-shoots, there is no lead from one shoot to a repetition and the search could entail heavy expenditure in diamond drilling. Australian Development continues to maintain ore reserves at about five years' life, but developments and new ore are lateral. Effort has not been made to plan deep drilling, which is the important work.

For some time gold mining has been depressed and the Government battery was out of action. This has now been reconditioned and there is marked revival in operations by the small mine owners.

Coal.—The great recovery in the coal-mining industry is reflected in the figures of the Joint Coal Board for the four weeks ended March 26, when exports overseas totalled 103,000 tons, of which 82,400 tons went to Japan. Overseas exports in the first twelve months of 1960 were up 120% on those of the corresponding period of 1959. Competition from other countries interested in the supply of coal to Japan is becoming keener. For some time past there has been increasing complaint about the loading facilities in the port of Newcastle and there is growing evidence that improved berthing and loading facilities in the New South Wales ports would cause a substantial reduction in shipping costs. In 1959 losses from industrial disputes were 1·68% of possible manshifts, compared with 3·21% in 1958. Production losses were 421,000 tons in 1959 and 691,000 tons in 1958.

Queensland.—There was a recovery in the production of most minerals in 1959 as compared with depressed conditions in 1957. Production of gold, copper, tin, and uranium increased but there was a lower production of lead, zinc, silver, rutile, and manganese ore. Figures for 1959 are: Copper, 48,206 tons, valued at £A15,032,645; lead, 49,947 tons, valued at £A4,433,200; silver, 4,436,209 oz., value £A1,813,824; tin, 1,680 tons, value £A978,312; zinc, 13,983 tons, value £A1,452,700; rutile, 20,299 tons, value £A1,219,233; zircon, 15,279 tons, value £A182,988; manganese ore, 4,881 tons, value £A73,228; uranium oxide, 730 tons, value £A6,475,267. Uranium production showed an increase of 479 tons.

Stainless Steel.—Stainless steel is now being made in Australia, at the plant of the Commonwealth Steel Co., Ltd., at Unanderra, close to the Port Kembla steelworks of Australian Iron and Steel.

The steel is made at the company's works at Waratah, Newcastle, by an electrolytic process and cast into 5-ton to 11-ton ingots, which are transported by rail to the hot-strip mill of Australian Iron and Steel. A Sendzimir mill, the only such mill in the Southern Hemisphere, is used.

Iron and Steel.—The first section—48 ovens—of a battery of 96 coke ovens at Australian Iron and Steel, Port Kembla, New South Wales, has commenced operation. The complete battery, to be finished in August, will have an annual capacity of 680,000 tons of coke and will increase the steelworks' capacity to 1,750,000 tons of metallurgical coke per year. By-products recovered will approximate 13,500 gal. of light oil, 20 tons of ammonium sulphate, and 5,500 gal. of light oil.

FAR EAST

May 14.

Malayan Iron Ore.—The 14 iron ore mines in production in Malaya turned out a record total of 1,106,042 tons during the first quarter of the current year, an increase of 477,100 tons over the corresponding period of 1959. The labour force employed at the mines went up from 4,454 in January to 4,778 at March 31. As Malaya has arranged to export some 4,750,000 tons of iron ore to Japan during the current fiscal year even greater production figures are expected for the second quarter. In the previous year Malaya exported just under 4,000,000 tons of iron ore to Japan.

The biggest producing State in Malaya is Trengganu, its single mine at Dungun turning out a total of 474,550 tons in the first three months of this year. Perak, which produced no iron ore six years ago, is now in second place having totalled 287,006 tons in the first quarter of 1960. Totals for the other three producing States for the first quarter were: Johore, 163,743 tons; Kelantan, 133,464 tons, and Kedah, 47,279 tons.

Mitsubishi Shoji Kaisha, Ltd., a Japanese industrial and trading concern, has opened a mining department in Singapore to provide prospecting services for the Malayan iron-ore industry. Two specialists from a sister company—Mitsubishi Metal Mining—are now stationed there. The local manager of Mitsubishi Shoji Kaisha, Mr. Chyozo Mandai, said: "At present we are prospecting in Johore Bahru and it is hoped that in future we shall do similar work in other parts of the Federation." A research laboratory is to be set up shortly either in Singapore or the Federation.

Kulim Rubber Plantations has announced that iron-ore deposits which may prove to be valuable have been found on the Sungei Toh Pawang Estate, in Kedah. Engineers have been engaged to advise as to the best method of assessing and exploiting these deposits and on their advice an option agreement has been signed granting a Chinese mining firm the right to prospect over an area of about 500 acres.

Tin.—As a result of Malaya's increased export quotas for the next quarter more tin mines are expected to open up. M. Georges Péter, chairman of the International Tin Council, has said in London that although the Council has decided to maintain total permissible exports in the 11th control period at 37,500 tons actual exports are expected to be about 36,300 tons.

A report from Bangkok is to the effect that Thailand is considering withdrawing from the International Tin Council unless more members were brought in and Thailand's own export quota was increased. This has caused concern in Malayan mining circles and Mr. P. A. Delme-Radcliffe, president of the F.M.S. Chamber of Mines, speaking in his personal capacity, said: "It must be perfectly clear that if any producing country which is in the present agreement does not join the new one then the remaining producing countries are unlikely to go into it either. No single producing country can expect to gain an advantage that way." He also said that it would "certainly be desirable that we should try to persuade America to take part in the new tin agreement as she is the biggest consuming country in the world. It would also be as well to have the other consuming and producing countries in." Mr. Sarit Tanarat, Thailand's Prime Minister, has said that his Government has decided to impose strict control in granting tin-mining concessions. Most of the tin miners in southern Thailand have dual nationality—one Thai and one foreign—and they are taking advantage of this privilege. The Ministry of Industry would be instructed to encourage Thai nationals in the mining industry and at the same time be very careful about giving concessions to persons of dual nationality.

Malaya's Industrial Progress.—Malaya's investment climate was most attractive and the country was making tremendous progress in its industrial development, said Mr. John V. Fleming, export sales manager of the Colorado Fuel and Iron Corporation, Pacific Coast Division, on his arrival in Kuala Lumpur. He was leading a group of American business men representing the World Trade Association of the San Francisco Bay Chamber of Commerce, which hopes to obtain closer trade relations.

India.—The Indian Government has accepted an offer made by the West German Government to supply geophysical equipment and scientists to further oil development in India, it is reported.

Mr. K. D. Malaviya, Minister for Mines and Oil, said recently at Nagpur that India would produce enough copper for domestic use by the middle of the third Five-Year Plan period and thereby save a considerable amount of foreign exchange now spent in importing the commodity.

A start has been made on building a Rs.200,000,000 aluminium factory at Pipri, near Rihand Dam, in the Mirzapur district. The factory is to be run by the Hindustan Aluminium Corporation, Ltd., a project which is the result of collaboration between the Kaiser Organization of the U.S.A. and Mr. G. D. Birla, an Indian industrialist. The plant is expected to produce about 20,000 tons of aluminium annually.

Sarawak.—Prospects for manufacturing Portland cement near Kuching have been considered by the Sarawak Geological Survey Department, a survey having shown that extensive supplies of the main raw materials, except fuel, existed in the country's First Division. Investigations carried out last year and earlier had outlined eight masses of limestone containing several hundred million tons of suitable rock near the main roads and rivers within 26 miles of Kuching. Similar limestone would soon be exported from North Borneo for making cement in Hong Kong by a new quarrying and limestone manufacturing concern which had recently invested more than $500,000 in the project.

SOUTHERN AFRICA

May 30.

Trade.—Over the first quarter of 1960 imports into the Union rose to £135,488,000 from £118,120,000 in the corresponding 1959 period; exports were respectively £112,517,000 and £97,395,000, and the respective trade deficits £22,971,000 and £20,725,000. Gold sales excluded from the foregoing returns were £57,900,000 in the first quarter of 1960 and £61,605,000 in the first 1959 quarter.

Strathmore Development.—The Strathmore Development Co., Ltd., an associate company of the Stilfontein and Buffelsfontein mining companies in the General Mining group, has purchased the mineral rights over about 920 claims adjoining the north-eastern corner of the Buffelsfontein lease area. These claims, part of the Lucas Block from which the Stilfontein, Hartebeestfontein, and Buffelsfontein lease areas were drawn, will be held for exploitation and/or disposal for the account of the holding company.

The two bore-holes on the farms Video and Vermeulenskraal Noord, south of the Presidents Brand and Steyn mines and west of Harmony, have been completed. In the V 1 bore-hole the Basal Reef was intersected at a depth of 9,232 ft. with values of 31 and 39 in.-dwt., in complete core recoveries; in V 2 the reef was faulted out. A third bore-hole, 5,200 ft. south-south-east of V 2, is being drilled and has already reached a considerable depth. The mineral rights of the farms are held by the Eastern Rand Extension, General Mining, and Lydenburg Platinum companies.

Diamonds.—The Central Selling Organization of the De Beers group, which organization markets diamond output on behalf of South African and other diamond producers, will negotiate this year the renewal of contracts with producers outside the Union. These contracts expire this year. The exceptionally high levels of diamond sales in 1959 are not expected to be repeated in 1960, but sales should be maintained at satisfactory levels.

Transvaal.—At East Rand Proprietary two winzes in the ultra-deep central section have penetrated well below 10,000 ft. from surface; the winze in the H system has reached a point 11,246 ft. below surface and the winze in the G system has approximately reached the 11,000-ft. mark. Reef development is progressing satisfactorily in the ultra-deep levels, where over the last year or so payability increased to 49% from 23% while values of the payable footage declined by 58 in.-dwt. Most of the footage sampled is still on the higher levels, above the 7,500-ft. horizon, due to the longwall stopes in the deeper levels requiring much less effort in this respect for an equivalent tonnage than in the smaller stope blocks in the shallower sections.

Orange Free State.—The possibility cannot be ignored that in the event of Freddies Consolidated Mines, Ltd., locating payable multi-banded Elsburg Reefs in the western section in tonnages not sufficient for the continuation of operations on the company's own account, a deal with Loraine Gold Mines, Ltd., may be negotiated. Exploration is to be conducted in the western Freddies section to test for the extension of Elsburg Reefs into the Freddies property from the Loraine mine. A reduction in the scale of development on the Basal Reef within the Freddies mine is now looming ahead, which reduction, if eventuating, would almost certainly be a prelude to the ultimate closure of the mine. In the meantime operations will be adjusted as closely as possible to a break-even point and the mine kept in production, providing the company's assets are not thereby unduly diminished. The outlook remains uncertain.

Natal.—The African Metals Corporation, which recently acquired the ferro-alloy works of another company as an extension of its own similar interests, is now proposing an increase of capital through a share issue to finance further extensions to its ferro-alloy plant and the establishment of a factory to produce graphite electrodes at its Kookfontein sites near Vereeniging. The factory will be operated in association with the Siemans-Plania group, will use such domestic raw materials as coal and tar-pitch, and will have an output of about 3,000 tons a year of electrodes. In addition to the proposed share issue mentioned the African Metals Corporation proposes a capitalization of a portion of the reserves already used to finance its activities through a bonus share issue, in the ratio of one bonus share for four held.

Central African Federation.—Rhodesia Broken Hill Development should derive substantial benefits from the installation of the Imperial Smelting furnace now being effected and expected to be commissioned early in 1962. Lead and zinc extraction will be raised from about 60% to over 85% from current ore, while about 200,000 long tons of the two metals will be recovered from high-grade oxidized accumulations. At capacity operation output of lead and zinc will be increased respectively to 28,000 and 55,000 long tons from about 14,400 and 30,000 long tons per year. Including ancillary installations the total cost will be £4,350,000. Of the £3,550,000 to be provided £3,000,000 will be raised by two convertible note issues, this year and in 1962, and the balance appropriated from profits. Under existing metal prices and barring the unexpected dividends should be maintained. With the new smelting furnace commissioned alongside existing plant the feed, as now planned, will consist of 200,000 tons of mined ore a year and 30,000 tons to 40,000 tons of accumulated dumped material, against a total treated of 264,628 tons and 217,200 tons in 1959 and 1958. Over 1959 the total ore reserves were increased by 725,000 short tons to 5,870,000 short tons, which, apart from extended development, gives the mine an effective life of about 25 years. Exploration is being continued at depth, while on surface several promising indications of ore continue to be explored in the vicinity of the mine. Several other properties of the company are now being examined.

Northern Transvaal and the Federation.—Features of the 1958–59 activities of Messina and its associates were the commissioning by M.T.D. (Mangula) of its second 22-ft. diameter Aerofall mill, extending the flotation section, and raising production to capacity levels; the erection of the custom copper smelter at Alaska Siding, which will treat output from the Mangula and Alaska mines of the group and suitable ores and concentrates from any outside sources and which is expected to be commissioned by about September, 1960; developing the Alaska copper mine, which will be commissioned with an output of about 500 tons of ore a day in the same month as the smelter; exploring the extension of mineralization from the mine, which in the period disclosed low-grade but encouraging values about 2 miles from the mine, and advancing further exploratory development in the Sanyati property,

where operations are to be accelerated. Prospecting operations on the Lomagundi nickel deposits, the Iron Mask pyrite occurrence, Darwendale chromite, and the Lucky Leap Year and Tufa limestone deposits were continued, as well as in exclusive prospecting areas totalling about 670 sq. miles.

In the Messina smelter pilot-plant tests were conducted to improve methods of extracting bismuth from Mangula concentrates. At Umkondo additional flotation cells installed improved recovery of concentrates to 84·12% from 76·9%. At Mangula underground drilling disclosed folding in certain zones and more recent work has revealed the presence of a second ore-body at depth below the main body, the best of the recent intersections being 2·49% Cu over 53 ft.; exploration is being continued. In two other zones exploration has disclosed payable tonnages, while in a third, old workings are being examined with a view to reclamation.

South and South-West Africa.—De Beers Consolidated Mines reported no outstanding progress in 1960 apart from the successful development of a diamond-synthesis process and a high level of production and sales. The trend in diamond sales and production is that supplies of the larger gem-stones continue below demand, supplies of smaller and lower-quality diamonds are adequate, and in the market for industrial diamonds the dominant factor has been the United States' Government stockpiling purchases, apart from which supplies would have been well in excess of demand. Increasingly severe competition is expected from the synthetic grit produced by the General Electric Co., U.S.A. The associated Consolidated Diamond Mines of South-West Africa is the most important producer of the larger good-quality diamonds. On balance, 1960 is expected to hold out favourable diamond trading prospects.

Research into industrial applications of diamonds has been intensified generally and has shown that synthetic grit can be used in both resinoid-bonded and metal-bonded grinding wheels, but that natural grit can be adapted for both sorts of wheels. A new diamond-drilling material has been introduced for specific operations. The general tendency is now to produce from run-of-mine material specially prepared and treated industrial diamonds for specific operations.

The De Beers group has not reported any major discoveries from continued prospecting operations in the Union, Bechuanaland Protectorate, and Northern Rhodesia, apart from further payable deposits being located on the farm Annex Kleinzee in Namaqualand. Small-scale operations were continued in 1959 in the Kaokoveld, South-West Africa, where the recovery improved to 5·48 carats from 3·83 carats per 100 loads. With the 1958 results in brackets, the 1959 returns of De Beers Mines were: Loads washed 8,096,243 (7,152,763); carats recovered 1,128,451 (968,230); carats per 100 loads 13·9 (13·5); average costs per carat 62s. (69s.). At Williamson Diamonds, Ltd., in Tanganyika, exploration at greater depth is projected and a small shaft is being sunk to facilitate sampling on the 300-ft. and 1,200-ft. levels. Reserves in the overlying gravels and the upper Kimberlite levels are adequate for many years of operations. Prospecting of other Kimberlite occurrences in Tanganyika has not yet disclosed payable deposits.

General.—Rand Mines, Ltd., is engaged on an extensive programme of exploration in the Union, South-West Africa, and Southern Rhodesia. Some areas have yielded encouraging results in the preliminary stages of prospecting, the prospects embracing precious and base minerals. The Rand Mines company has found it advantageous to establish separate subsidiary companies to handle the exploration, administrative, and new business generally in connexion with the exploration programme. Rand Mines Rhodesian Exploration Co. (Private), Ltd., was formed to undertake prospecting in the territory, particularly for copper, in the Karoi district of Southern Rhodesia, where the company has two exclusive prospecting orders over 500 sq. miles. Encouraging results have been reported from the Karoi operations. More recently, Rand Mines Exploration Co. (Pty.), Ltd., was established to administer other exploratory activities.

Trade Notes

Brief descriptions of developments of interest to the mining engineer

Hydraulic Mines Tractor

Some particulars have just been released of a flameproof diesel hydraulic mines tractor by **Hunslet Engine Co., Ltd.,** of 125, Jack Lane, Leeds. This is a 25-h.p. rubber-tyred four-wheel drive vehicle, as shown in the illustration and is the first to go into service in a British colliery.

The tractor is fitted with slew steering

which allows great manœuvrability and precision of control, enabling it to operate alongside conveyors without damaging either the conveyor or the mine arches. Acute corners can be negotiated, turning radius being only 5 ft. 6 in. This type of steering obviates the need for a differential lock and also facilitates the use of a variety of ancillary equipment. The tractor is controlled by a throttle, a forward/reverse selector, and two levers, each of which operates the brakes on a pair of wheels. The controls are conveniently arranged for use from alternative driving positions, one for each direction of travel. With this arrangement the driver can always face the direction in which the tractor is moving, thus facilitating steering and eliminating blind spots.

A Perkins "Three 152" water-cooled three-cylinder diesel engine, with chromium-plated liners and mechanical governor is incorporated, de-rated to develop 25 h.p. net at 1,650 r.p.m. The engine is started by an hydraulic starter. Transmission from the engine is through a torque converter to an epicyclic forward and reverse gearbox, then through reduction and transfer gearing, multi-plate clutches, and worm drives. The worm drives are incorporated in each wheel. This unique transmission system facilitates the servicing of clutches, brakes, and final drive and enables a four-wheel drive tractor with large-diameter tyres to be built down to a width of 3 ft.

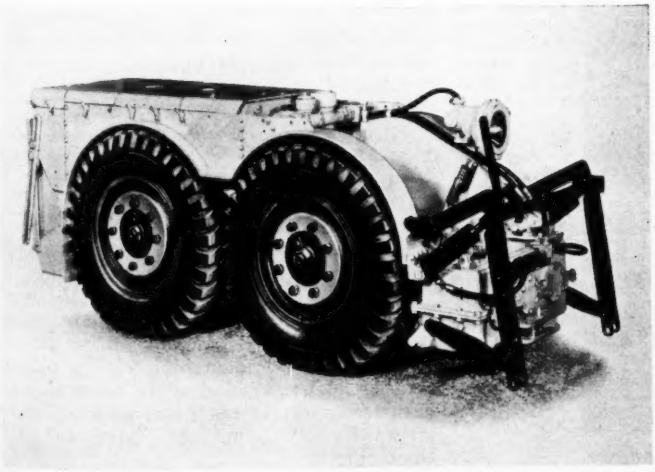
The stainless-steel exhaust-gas conditioner is constructed on the Hunslet "Jet" principle to ensure maximum cleansing of the exhaust gases and safety of operation even when working over undulating ground. An exhaust conditioner low water level engine shut-off device is fitted and the whole of the exhaust system, including the conditioner, is waterjacketed. The gases from the conditioner are diluted with air from the fan before exhausting to atmosphere.

The machine is described as of particularly rugged construction and any load likely to be encountered underground can be superimposed on the tractor as the total load capacity of the tyres is over 12 tons. Alternatively the load can be hauled on rubber-tyred trailers which follow accurately in the path of the tractor or on steel skid pans. The skid pans can conveniently form a baseplate for pallet loads and in addition can be quickly converted into articulated trailers.

The basic tractor incorporates an hydraulic pump and the frame is designed for the attachment of an hydraulic linkage to which the following items are readily fitted : Angle-dozer, low-lift shovel (2 tons capacity), fork-lift (2 tons capacity), crane, articulated trailer coupling, or skid pan. In addition winches are available driven through the torque converter or by the hydraulic pump.

The Hunslet MT.25 was developed as a basic multi-purpose tractor for material handling, development work, and recovery duties underground. It is obvious that such a versatile and flameproof machine is also suitable for duties on the surface, especially where there are space limitations.

Brief specification : Length over drawgear,



Hunslet Mines Tractor.

8 ft. 11½ in.; width overall, 3 ft.; height overall, 3 ft. 5 in.; carrying capacity, on top of tractor, 27,000 lb., on carrying plate, 4,000 lb.; drawbar pull at starting, 4,200 lb.

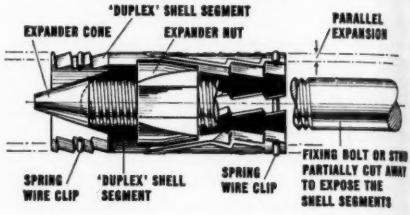
Some notes supplied by **Perkins Engines, Ltd.,** of Peterborough, give a more detailed specification and description of the diesel engine from which the following is extracted: Perkins Three 152 (flameproof). Cubic capacity, 2·5 litres, b.h.p. rating (gross) 29 at 1,650 r.p.m., maximum torque 98 at 1,200 r.p.m.

Duplex Anchor for Roof Bolting

A new design of anchor for use in rock bolting and roof control has recently been announced by the **Rawlplug Co., Ltd.,** of Cromwell Road, London, S.W. 7. The body consists of three high-grade malleable iron castings held together by steel circlips. Expansion is effected by the action of two independent cones which are housed within its form. One cone is suitably threaded and acts as the expander nut. The other cone is positioned in the base of the castings, the castings and cone being formed with matching tapers. Expansion is obtained by screwing the associated stud or bolt into the expander nut until the head of the stud or bolt reaches the head of the cone. Continued screwing has the effect of pressing the cone down on the tapered face, thus forcing the body castings outward. At the same time the expander nut is rising and also forces the castings outwards, thus effecting a parallel expansion of the whole of the surface of the anchor.

Duplex Bolt Anchor.

Diagram showing construction of Rawlplug Duplex Anchor



This feature is of particular value when working in ground of a soft character; an anchorage can be obtained that normally would not be possible with other types of units. When working in hard ground high-tensile studs or bolts can be used. The sizes for rock bolting are ⅝ in., ¾ in., and 1 in. tapped B.S.W. Destruction tests in hard material have shown that the anchoring unit always stands up to the load applied, the stud (bolt) or material failing first.

Load Tests.—Recorded loads using 28-ton to 30-ton studs: ⅝-in. stud broke at 8·9 tons; ¾-in. stud broke at 11·0 tons, and 1-in. stud broke at 19·7 tons.

Torque.—Recommended loadings (minimum): ⅝-in., 80 lb./ft.; ¾-in., 125 lb./ft., and 1-in., 220 lb./ft.

Hole Boring.—To obtain maximum efficiency it is desirable that drill sizes be as detailed below:—

Unit.	*Drill size, in.* *Min.*	*Max.*
Duplex ⅝-in. . . .	1 5/16	1⅜
Duplex ¾-in. . . .	1 7/16	1½
Duplex 1-in. . . .	1¾	

For anchoring of cabling and service piping within shafts the Duplex anchor offers a distinct advantage, as when a selected stud has been driven home in the Duplex anchor it gives a rigid projection on to which brackets and attendant units can be placed prior to final tightening of the hexagon nut. This feature is of particular interest as it allows for a "lining up" prior to final tightening.

Personal

G. P. BENNETT is returning from South Africa.

A. A. C. BREWIS is home from India.

F. E. BUCH, formerly general manager of Mufulira Copper Mines, has been appointed a director of the principal companies in the Rhodesian Selection Trust Group.

H. F. BURTON, of Mackay and Schnellmann, has returned from Burma and has now left for Persia on a second tour of duty there.

A. W. CLARK has left for Liberia.

GUY FINLAYSON is home from Turkey.

J. F. INCE is now a director of the Rhodesian Corporation and of the Kwahu Mining Co. (1925).

J. W. LAW, secretary of Powell Duffryn Technical Services, Ltd., has been appointed a director of the company.

W. L. G. MUIR has left for Sierra Leone.

DAVIDSON NICOL has been appointed Principal of Fourah Bay College, the University College of Sierra Leone.

C. HARVEY RICHARDS is leaving to take up the appointment of general manager to the Cyprus Sulphur and Copper Company.

G. A. SCHNELLMANN has returned from a short professional assignment in Nigeria.

E. D. SHEARN has been re-elected chairman of the Council of the Malayan Chamber of Mines and J. N. DAVIES re-elected vice-chairman for the ensuing year.

D. J. SIMMONS has recently visited South-West Africa and Eire.

C. W. TACHIE-MENSON is here from Ghana to take up his appointments as a director of Ariston Gold Mines (1929), Ltd., and Ghana Main Reef, Ltd.

HARRY V. WARREN, Professor of Geology and Geography in the University of British Columbia, is visiting Great Britain to pursue his studies of lead and zinc in rocks, soils, and trees. Dr. Warren is also attending the International Geological Congress in Copenhagen in August.

W. G. YUILL, of Mackay and Schnellmann, is on a tour of Central and South America and is expected back towards the end of July.

THE INSTITUTION OF MINING AND METALLURGY

Elections and Transfers

Member.—Jack Chambers CHASTON, A.R.S.M., Ph.D. (*Harrow*); Ronald Alfred WELLS, B.Sc., F.R.I.C. (*Walton-on-Thames*).

Associate Member to Member.—Edward DAVIES, B.E. (*Mount Isa*); Frank FAIRBAIRN (*Egremont*); Kenneth Frederick Gordon HOSKING, Ph.D., M.Sc. (*Camborne*); Peter Foreman RANSBY, B.Sc. (*London*).

Associate Member.—Kenneth Henry BRETT, A.R.S.M., B.Sc. (*Broadstairs*); Vernon Walter HALL, A.C.S.M. (*Nchanga*); Victor John MOORE (*Kitwe*).

Student to Associate Member.—Ronald David BUTLER, A.R.S.M., B.Sc. (*London*); Harold James CAVE, A.C.S.M. (*Mufulira*); Ean Trevor DANIELL, A.C.S.M. (*Kampar, Malaya*); James Dighton MOORE, A.C.S.M. (*Kingston*); Richard Gerald Anthony PEARCE, A.R.S.M., B.Sc. (*Copper Cliff*); Ronald Bruce STOKES, A.C.S.M. (*Vancouver*); Michael John SWEET, A.C.S.M. (*Sungei Besi*); Trevor Orlando TRENNERY, A.C.S.M. (*Mpanda*).

Student.—Edward Philip ANTROBUS (*Johannesburg*); David Charles BRINK (*Johannesburg*); John Richard Vivian CADDY (*Truro*); Anthony Stewart CHRISTIANSON (*Johannesburg*); Ciarán James FORRISTAL (*Dublin*); Anthony Bertram HOLLAND-BATT (*Normandy, Surrey*); Volker Franz IRSIGLER (*Krugersdorp*); Roy Lardner, B.Sc. (*Kitwe*); Roger MARSHALL (*Ipswich, Queensland*); Gerald Frank MAYES (*Camborne*); Anthony Joseph MIHULKA (*Johannesburg*); Robert NEWBERY (*London*); Ian Nicholas RIDLEY (*Newcastle-upon-Tyne*); Chong Tat SHIN (*Camborne*); Rana M. SULTAN, B.Sc. (*Warcha, West Pakistan*); Keith Victor GODFREY (*Bristol*).

Metal Markets

During May [1]

Copper.—Rising London Metal Exchange warehouse stocks at the beginning of May, coupled with a broad reversal of sentiment, helped to keep price levels [2] from rising too steeply following the breaking out of strikes at Anaconda's Potrerillos and El Salvador properties in Chile on May 2. Although prices did rise on May 3 and 4 they were down again on May 5 and by May 9 they were as much as £10 a ton lower than at the beginning of the month, when they were already some £20 a ton below the April peak. Subsequently easiness persisted, despite the continuation of the Anaconda strikes until nearly the end of the month and threats of sympathy strikes at other Chilean mines (which were dropped when the recent earthquakes hit the country) and despite the uncertain political situation in the Belgian Congo.

The Copper Institute's April statistics showed conclusively that present world production is running well ahead of consumption, good though the latter is. The Summit breakdown was the only disturbing factor so far as the downward price trend was concerned; for two or three days immediately after the failure of the Paris talks European consumer buying increased because of fears of a re-intensification of the cold war, resulting in maintained, if not increased, Western defence expenditure. In consequence prices rose, but within a short space of time buying activity had fallen off again. The reduction in demand and the settlement of the Anaconda strikes at the end of the month caused further falls until, all in all, official copper values finished some £20 a ton below the levels ruling on May 2.

U.K. copper consumption in March amounted to 67,782 tons, of which 54,389 tons was refined. Production of primary refined metal in the U.K. in the same month totalled 7,547 tons, while production of secondary was 10,776 tons. Stocks of refined copper at the end of March amounted to 39,878 tons, against 45,134 tons at the end of February. Blister stocks totalled 12,599 tons, as compared with 10,845 tons the previous month.

Tin.—As most traders and observers had expected

[1] Recent prices, pp. 336, 376.

[2] See Table, p. 376.

the International Tin Council decided at its meeting at the beginning of May to maintain the third-quarter export quotas unchanged at 37,500 tons, although a subsequent statement indicated that its members expected actual exports to reach 36,300 tons—about 1,000 tons more than this quarter's likely exports. At the same meeting it withdrew the Buffer Stock manager's authority to operate in the middle price range (£780 to £830 a ton) after June 31, thus bowing to recent criticism from dealers of the way his constant buying and selling in the past few months has held prices [1] at very near £790 a ton with only minor day-to-day variations.

This effective forecast of a generally easier supply position during the rest of the year was immediately reflected in a lessening of buying interest. At the same time the Buffer Stock manager's operations ceased, although they need not have done, of course, until the end of June, and prices were therefore allowed to fall somewhat below recent levels. In fact at the end of May they had fallen to within a few shillings of £780, below which the Buffer Stock manager must step in.

Nevertheless consumption remains good and the present lack of new buying is due mainly to continued caution over the outcome of the current United Nations meeting in New York over proposals for a new Tin Agreement when the present one expires next summer.

U.K. tin consumption in March totalled 2,191 tons, while production of new metal amounted to 2,743 tons, as compared with 2,144 tons in the previous month. Stocks on March 31 were 10,677 tons, against 10,240 tons at the end of February.

Lead.—Lead continued to make a good overall showing in May with prices, as in April, never below the £75 mark.[1] Generally speaking United Kingdom and European consumption was again maintained at excellent levels and there is every indication of a continuation of this over the next few weeks, if not longer. Some idea of just how good consumption has been recently other than in the United States can be obtained from figures published towards the end of May for total deliveries in March; they were some 13,000 tons higher than the average monthly figure for both 1958 and 1959.

The easier tone of the market towards the end of May was possibly caused by a shift of sentiment in sympathy with the shake-out in copper prices. There were also rumours of new arrivals of foreign metal and in the existing thin state of the market these were sufficient in themselves to cause some slackening of the previous upward price trend, if not an actual fall. Such material has, of course, been attracted here by each successive peak in prices. The only encouraging feature is that prices needed to go rather higher this time than previously.

United Kingdom stocks at the end of March amounted to 41,248 tons, as compared with 42,043 tons at the end of February. Lead production in this country in March totalled 9,522 tons, against 7,253 tons in February. Consumption was 35,066 tons, keeping the quarter ahead of the same period last year.

Zinc.—Rather freer arrivals of American smelted zinc in this country during May kept London Metal Exchange prices [1] for the most part rather lower than in April. The improvement in the nearby supply position in the latter half of the month was such that a small contango showed itself for a few days—the first time such a feature has been seen on the London market for some months past other than temporarily at mid- and end-month settlement dates. On the other hand offerings of Continental metal have been rather less than of late, although high-grade Russian zinc has been selling quite well at a premium of £2 a ton or less over g.o.b., as has similar Commonwealth metal at a £4 premium.

The rather easier supply position is no doubt also due in part to the fact that only now are the effects of the removal of last year's voluntary restrictions on supplies beginning to make themselves really felt in both increased output and shipments. Until now the freer supplies have been basically replenishing the pipeline, but in future supplies to the market could become progressively more plentiful. This is not to say, however, that consumption has fallen off. On the contrary, so far as the U.K. is concerned, it continues at what could be record levels. In the first quarter total consumption in this country was no less than 20% higher than in the corresponding period last year.

In March consumption amounted to 35,268 tons. Stocks totalled 51,064 tons, of which consumers held 18,684 tons. Production amounted to 7,110 tons compared with only 5,214 tons in February.

Iron and Steel.—May saw no great change in the iron and steel position in the United Kingdom; producers were extremely busy and the flow of orders remained impressive. The pressure consumers are placing on the works has kept production at record levels and deliveries are lengthening generally, the longest delays being for special steels. In many instances the mills are quoting delivery of one year or over.

Sheet steel is still tight and in spite of maximum efforts from home mills the motor industry's and other sheet consumers' requirements are at such a pitch that users have resorted to large-scale imports. In the first four months of this year arrivals of foreign sheets jumped to over 192,000 tons, as compared with 53,600 tons in the corresponding period of 1959. However, sheet consumers are not alone in having to look to overseas sources of supply. The re-rolling industry has lately been buying marginal tonnages of billets because of a shortage of domestic material, while a coil-spring manufacturer has stated that he has had to import spring steel from as far away as Japan to maintain production.

The heavy steel trade is also going through a very busy spell and the majority of the mills are working at capacity. The railway equipment makers, however, are not as fortunate and output is running well below average.

Substantial tonnages of British iron and steel continue to be shipped overseas and in the first four months of the year exports increased to 1,213,236 tons, a rise of 38% over the same period of 1959.

Iron Ore.—Imports of iron ore into the United Kingdom in the January–April period of 1960 rose sharply, to reach a total of 5,335,745 tons, as compared with 3,535,214 tons in the same four months of a year ago. Sweden was the biggest ore supplier to this country, in that period shipping more than 1,480,000 tons, followed by Algeria (763,809 tons), and Venezuela (560,491 tons). Meanwhile the Iron and Steel Board and the British Iron and Steel Federation are understood to

[1] See Table, p. 376.

have agreed on a major increase in U.K. iron-ore production. It is reported that output will increase from the current rate of 16,000,000 to 17,000,000 tons annually to over 25,000,000 tons by the end of the 1960's.

Aluminium.—The Imperial Chemical Industries/Aluminum Co. of America acquisition at the beginning of May of Almin, Ltd., parent of (among others) International Alloys, Ltd., this country's largest secondary aluminium ingot producer, has of course given ALCOA some degree of control over yet another big section of the United Kingdom aluminium industry. More than that, it has given it a chance to do in this country what it reportedly already does in the U.S.A. in company with the other major U.S. primary aluminium producers—give a concealed discount on virgin metal sales by means of its scrap-consuming subsidiaries paying high rates for return scrap.

Apart from this the other event of significance in May was the publication of two sets of figures which augur very well for the British aluminium industry generally this year. The Ministry of Aviation's figures for U.K. fabricators' total despatches of aluminium semis in the first two months of the year were released mid-way through the month. If the monthly rate established by the end of February has been kept up—and there seems no reason to doubt it—the final figures for first-quarter despatches this year should show an increase of some 20% over the corresponding period of 1959, with the biggest advance (about 11,600 tons) in despatches of rolled products, including, of course, sheet and strip.

Total United Kingdom consumption of aluminium and aluminium alloys last year was a record. This year's could be an even bigger record, for first-quarter imports of all forms are well up, according to the Trade and Navigation Accounts for April. In the first four months of this year they amounted to no less than 127,172 tons—an advance of 63% on the first four months of 1959.

Antimony.—The United Kingdom market for antimony was quiet in May with prices unaltered throughout the month at £197 10s. a ton for English regulus 99·6% and £190 a ton for 99% material. From the United States, however, there were two pieces of news. The first concerned the completion of arrangements by the Commodity Credit Corporation for a three-way barter with Denmark and Brazil whereby so far as the U.S. was concerned it would receive some 850 tons of antimony ore from Brazil for processing by the National Lead Company and subsequent addition to the supplemental stockpile. The other was the announcement by the U.S. Bureau of Mines that United States domestic consumption of primary antimony in 1959 was up by 17% over the figure for 1958. In spite of this, the Bureau stated, the increased demand was more than met by supplies. Domestic output (at 9,200 tons) was up by 7% due to increased production of by-product antimonial lead and a doubling of production of regulus in the second half of the year. Imports (up 34% on 1958) were largely taken care of by Yugoslavia, the United Kingdom, and Belgium–Luxembourg—which supplied 81% of the total—while Britain alone supplied 71% of the total U.S. imports of antimony oxide.

Arsenic.—May, like April, was another featureless month so far as the arsenic market was concerned and quotations were again unchanged at £400 a ton for the metal and £40 to £45 a ton, ex store, for the trioxide.

Bismuth.—Bismuth trading was again featureless in May and the quoted price is still a nominal 16s. a lb. for one-ton lots, ex warehouse.

Cobalt.—Production of cobalt, which was ahead of demand last year, will probably be ahead again this year. Union Miniére du Haut Katanga has just brought into production another refinery with an initial capacity of 1,750 tons a year, which, it is reported, is to be raised later to 3,500 tons. On the other hand, the figures for United States consumption last year, which was up 30% on 1958, make rather more heartening reading. Prices have shown no change in recent weeks, open-market metal in the United Kingdom being still quoted at 12s. a lb. delivered, while the U.K. contract price remains at 10s. 9d. a lb.

Cadmium.—It is some little time now since the cadmium market showed any new features of note. U.K. and Empire refined metal in 1-cwt. lots is still priced at 10s. 6d. a lb. Foreign metal continues to fetch something of a premium at 10s. 6d. to 10s. 9d. a lb.

Chromium.—May was another featureless month for chromium when considered from the market viewpoint and quotations were again unchanged at 6s. 11d. to 7s. 4d. a lb. for metal of 98% to 99% purity.

Tantalum.—Tantalum ore continued to sell in May at its recently-established price of 700s. to 750s. a unit.

Platinum.—There has been rather less consumer interest in open-market platinum recently, although it is now quoted in this country at £28 5s. to £28 15s. per troy oz., against £28 to £28 10s. at the end of April. On the other hand the market for U.K. and Empire refined—quoted at £30 5s.—is quite healthy, despite reports from the U.S.A. during the month that research and improved operating methods have reduced the amount of metal likely to be required in future by petroleum refiners. Since the petroleum industry is the largest single outlet platinum producers have, the future will no doubt depend increasingly on research into new uses. However, it is worth remembering the statement to shareholders made earlier this year by the chairman of Rustenburg Platinum Mines, in which he said that he foresaw platinum consumption rising gradually whether the petroleum industry's usage went up or not.

Iridium.—The iridium market has been largely featureless for some little time past and quotations throughout May showed no change from those of recent months, still varying from £23 to £26 15s. a troy oz.

Palladium.—Palladium, like iridium, was featureless from the market standpoint in May and prices remained at their April levels (£8 10s. to £9 7s. 6d. a troy oz.).

Osmium.—Osmium is now quoted at £22 to £25 per troy oz.

Tellurium.—Despite recent statements to the effect that tellurium is in ample supply the world's major producers raised their prices again towards the end of May. They are now asking $3·50 per lb., against $3 previously. In this country tellurium lump and powder is now quoted at 25s. a lb. (21s. 6d. to 25s. previously) and small quantities of tellurium sticks of 99·5% purity are now on offer at 40s. a lb.

Tungsten.—The tungsten ore market has been

firm for the most part in recent weeks and c.i.f. Europe prices for Contract "B" material rose during May from 145s. to 152s. a long ton unit to 155s. to 159s. The depression caused towards the end of April by reports of low-priced sales of Russian material was completely shaken off by the beginning of May and since then, with Continental enquiry a particular feature of the market, especially in the first half of the month, prices have been gradually rising to something like their peak January–February levels. Apart from the Continent, Japan was also a customer during May for good quality material. The Board of Trade had no difficulty in disposing of its nominal quota and more some time before the end of the month, although its sales of Australian scheelite have lagged, now that consumers can buy improved Korean material.

Nickel.—A feature of the nickel scene in May was the announcement by the International Nickel Co. of Canada that work was to start on a new ore-body in the Clarabelle and Lady Lakes area of Sudbury. However, the Clarabelle open-pit project, which is due to begin production late next year, is not intended so much to increase the company's output as to replace tonnage now being obtained from the other Inco mines. Operations at the United States Government's Nicaro plant in Cuba are now affected, like those at the Freeport Nickel Company's Moa Bay installation, by the new 25% tax levied by the Cuban Government. All through May Nicaro has been waiting to obtain customs clearance for its normal monthly shipment for April on which it has so far refused to pay the new tax.

The quotation for refined nickel delivered in lots of 1 ton and over remains £600 a ton.

Chrome Ore.—Rhodesian chrome ore producers hit back in May at Transvaal producers' recent attempts to capture more of the market for low-grade Transvaal concentrates, which are now priced at £8 5s. a ton c.i.f., whereas Rhodesian metallurgical ore is quoted at £15 5s. In reply to charges that reserves of metallurgical ore are rapidly diminishing, they have pointed out that the Northern part of the Great Dyke is as yet virtually unworked and has sufficient reserves of material to maintain a high rate of production for hundreds of years to come. As regards the U.S. wheat—Turkish chrome barter, it was reported during May that some chrome suppliers were likely to hold out for better prices than those currently in force before making available sufficient material to meet U.S. requirements. More recently, however, it has been reported that several U.S. companies have submitted acceptable bids involving some 15,000 tons of ferro-chrome for conversion in the United States and elsewhere. At the same time the recent political developments in Turkey have cast some doubts at the time of writing over the ultimate fate of the barter.

Molybdenite.—The molybdenite market has shown no new features since the end of April. Some anxiety has been expressed about a temporary shortage but this is discounted by many people. American Metal Climax material f.o.b. mines is still quoted at 8s. 11d. per lb. of Mo contained, while material from other sources remains at 9s. 3½d. per lb. c.i.f.

Manganese Ore.—The manganese ore market remains just as depressed as it has done for some months past, with prices for 46% to 48% ore still quoted at a nominal 68d. to 73d. per unit of metal contained, c.i.f. Europe.

Tin, Copper, Lead, and Zinc Prices

Tin, minimum 99·75%; Copper, electro; Lead, minimum 99·75%; and Zinc, minimum 98%, per ton.

Date	Tin		Copper		Lead		Zinc	
	Settlement	3 Months	Spot	3 Months	Spot	3 Months	Spot	3 Months
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
May 11	786 10	784 5	249 5	243 15	77 13¾	76 11¼	92 11¼	91 12½
12	787 0	785 15	249 5	243 15	77 13¾	76 8¾	91 17½	91 13½
13	785 0	784 5	243 5	239 15	78 7½	76 15	91 2½	91 12½
16	783 10	782 15	242 15	239 12½	77 8¾	76 11¼	91 17½	91 13¾
17	785 10	784 15	244 2½	240 7½	77 13¾	76 16¼	92 5	91 13½
18	786 0	785 15	248 12½	244 12½	77 16¼	77 1¼	92 2½	91 18¾
19	785 10	785 5	250 5	246 12½	77 18¾	77 1¼	92 3¾	92 3¾
20	785 10	785 5	250 5	246 12½	78 1¼	77 6¼	91 17½	92 1½
23	784 10	784 5	247 15	245 5	78 3¾	77 12½	91 12½	91 17½
24	781 10	782 5	248 2½	245 2½	78 11¼	77 18¾	91 8¾	91 15
25	783 0	783 5	240 15	239 17½	77 11¼	77 3¾	90 15	91 1½
26	784 0	783 15	240 15	239 12½	77 6¼	77 7½	90 16¼	90 18¾
27	782 10	783 15	237 17½	236 17½	75 13¾	76 13¾	91 8¾	91 2½
30	781 0	781 15	237 7½	236 2½	75 17½	76 17½	91 3¾	90 16¼
31	782 10	783 15	238 7½	236 17½	75 17½	76 17½	91 1¼	90 16½
June 1	782 10	783 15	240 15	238 17½	76 3¾	76 8¾	91 3½	90 17½
2	786 0	786 15	245 7½	242 7½	76 1¼	76 8¾	91 17½	91 6¼
3	786 10	786 15	246 17½	242 15	76 3¾	76 6¼	91 13¾	90 16½
6	—	—	—	—	—	—	—	—
7	785 10	786 5	248 7½	243 17½	75 6¼	76 1¼	90 17½	90 11¼
8	785 10	785 5	244 17½	240 12½	73 11¼	74 13¾	89 17½	89 16½
9	790 10	789 15	245 2½	240 17½	74 2½	74 7½	90 0	90 1½

Statistics

TRANSVAAL AND O.F.S. GOLD OUTPUTS

	April		May	
	Treated Tons	Yield Oz.*	Treated Tons	Yield Oz.*
Blyvooruitzicht	121,000	80,496	128,000	84,119
Brakpan	143,000	17,318	146,000	17,419
Buffelsfontein‡	145,000	57,420	148,000	58,635
City Deep	109,000	22,841	119,000	23,590
Cons. Main Reef	63,000	13,149	62,000	12,852
Crown Mines	186,000	31,529	193,000	33,478
Daggafontein	233,000	47,189	233,000	47,156
Dominion Reef	44,000	350	40,000	320
Doornfontein‡	100,000	40,510	105,000	42,263
D'rb'n Roodeport Deep	186,000	34,330	198,000	36,095
East Champ D'Or‡	12,500	310	12,500	331
East Daggafontein	107,000	18,192	106,000	18,020
East Geduld	129,000	38,055	136,000	40,120
East Rand P.M.	209,000	53,018	227,000	55,659
Eastern Transvaal Consol	19,100	6,557	19,400	6,560
Ellaton‡	29,000	6,818	30,000	7,064
Freddies Consol	56,000	12,802	60,000	13,470
Free State Geduld	95,000	81,956	95,000	82,358
Geduld	70,000	12,636	72,000	12,962
Government G.M. Areas‡	52,000	10,809	54,000	10,902
Grootvlei Proprietary	210,000	43,686	215,000	44,722
Harmony Gold Mining	151,000	61,156	160,000	64,828
Hartebeestfontein‡	120,000	55,800	120,000	55,800
Libanon	117,000	27,675	117,000	27,698
Loraine	81,000	17,213	82,000	17,425
Luipaards Vlei‡	120,000	13,487	120,000	13,423
Marievale Consolidated	96,000	23,616	99,000	24,180
Modderfontein East	131,000	12,707	136,000	13,151
New Kleinfontein	75,000	10,155	79,000	10,266
New Klerksdorp‡	11,300	1,284	11,700	1,305
President Brand	120,000	97,131	118,000	95,606
President Steyn	105,000	40,395	105,000	40,236
Rand Leases	185,000	28,028	186,000	28,004
Randfontein‡	183,000	12,988	173,000	12,344
Rietfontein Consolid't'd.	16,000	4,210	16,000	4,131
Robinson Deep	45,000	10,172	42,000	9,851
Rose Deep	22,000	3,852	23,000	4,362
St. Helena Gold Mines	158,000	53,727	167,000	56,786
Simmer and Jack	76,000	13,488	74,000	13,391
S. African Land and Ex.	97,000	20,129	98,500	20,440
S. Roodepoort M.R.	29,000	6,969	30,000	7,230
Spaarwater Gold	10,700	3,355	11,000	3,418
Springs	102,000	14,280	102,000	14,251
Stilfontein Gold Mining‡	162,000	72,900	167,000	75,150
Sub Nigel	66,500	15,225	66,500	15,155
Transvaal G.M. Estates	6,800	1,694	7,600	1,903
Vaal Reefs‡	98,500	44,325	99,500	44,775
Van Dyk Consolidated	70,000	11,794	75,000	12,421
Venterspost Gold	130,000	33,586	130,000	34,093
Village Main Reef	30,200	4,687	32,700	4,566
Virginia O.F.S.‡	136,000	29,240	136,000	28,560
Vlakfontein	52,000	18,440	52,000	18,700
Vogelstruisbult‡	85,000	18,343	85,000	18,369
Welkom Gold Mining	100,000	31,522	102,000	32,252
West Driefontein‡	130,000	120,097	130,000	120,055
West Rand Consol.‡	209,000	21,274	217,000	22,228
Western Holdings	150,000	100,056	150,000	100,146
Western Reefs	144,000	40,608	145,500	41,104
Winkelhaak	83,000	25,731	85,000	26,776
Witwatersrand Nigel	19,500	4,383	19,800	4,389

† 249s. 8d. * 249s. 5d. ‡ Gold and Uranium.

COST AND PROFIT IN THE UNION

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Mar., 1959	16,743,500	68 0	45 4	22 8	25,934,881
April	—	—	—	—	—
May	—	—	—	—	—
June	17,845,100	69 1	45 2	23 11	28,473,191
July	—	—	—	—	—
August	—	—	—	—	—
Sept.	18,214,200	70 5	45 2	25 3	30,140,529
Oct.	—	—	—	—	—
Nov.	—	—	—	—	—
Dec.	17,670,000	72 2	45 10	26 4	30,559,937
Jan., 1960	—	—	—	—	—
Feb.	—	—	—	—	—
Mar.	17,464,400	72 8	46 5	26 3	30,105,571

* 3 Months.

PRODUCTION OF GOLD IN SOUTH AFRICA

	Rand and O.F.S.	Outside	Total
	Oz.	Oz.	Oz.
April, 1959	1,616,891	36,815	1,653,706
May	1,641,990	30,371	1,672,361
June	1,665,503	34,465	1,699,968
July	1,700,968	48,414	1,749,382
August	1,699,098	36,052	1,735,150
September	1,701,485	36,567	1,738,052
October	1,718,916	33,576	1,752,492
November	1,688,379	34,903	1,723,282
December	1,662,043	31,309	1,693,352
January, 1960	1,701,110	34,651	1,735,761
February	1,675,248	38,859	1,714,107
March	1,664,514	38,744	1,703,258

NATIVES EMPLOYED IN THE SOUTH AFRICAN MINES

	Gold Mines	Coal Mines	Total
July 31, 1959	381,190	33,295	414,485
August 31	377,257	32,994	410,251
September 30	371,813	32,903	404,716
October 31	365,833	32,567	398,400
November 30	358,746	32,067	390,813
December 31	354,058	31,963	386,021
January 31, 1960	372,254	31,993	404,247
February 29	385,027	32,144	417,171
March 31	388,860	30,696	419,556

MISCELLANEOUS METAL OUTPUTS

	4-Week Period To May 8		
	Tons Ore	Lead Concs. tons	Zinc Concs. tons
Broken Hill South	19,400	3,082	3,528
Electrolytic Zinc	16,452	917	4,338
Lake George	15,252	1,290	2,485
Mount Isa Mines**	49,281	3,850†	2,212
New Broken Hill	47,980	4,998	11,086
North Broken Hill	27,374	5,298	5,709
Zinc Corp.	56,850	7,281	10,053
Rhodesia Broken Hill*	—	—	—

* 3 Months. ** Copper 1,940 tons. † Metal.

RHODESIAN GOLD OUTPUTS

	April		May	
	Tons	Oz.	Tons	Oz.
Cam and Motor	—	—	—	—
Falcon Mines	20,400	3,937	20,500	3,935
Globe and Phœnix	6,100	3,329	—	—
Motapa Gold Mining	—	—	—	—
Mazoe	3,157	—	3,255	—
Coronation Syndicate	12,093	—	11,939	—
Phœnix Prince*	—	—	—	—

* 3 Months.

WEST AFRICAN GOLD OUTPUTS

	April		May	
	Tons	Oz.	Tons	Oz.
Amalgamated Banket	60,214	13,025	53,068	12,191
Ariston Gold Mines	40,350	13,372	41,080	12,956
Ashanti Goldfields	35,000	29,550	35,500	29,150
Bibiani	32,000	7,050	33,000	6,400
Bremang	—	5,043	—	5,189
Ghana Main Reef	11,267	4,479	10,550	4,382
Konongo	7,220	3,580	7,400	3,550
Lyndhurst	—	—	—	—

PRODUCTION OF GOLD AND SILVER IN RHODESIA

	1959		1960	
	Gold (oz.)	Silver (oz.)	Gold (oz.)	Silver (oz.)
January	46,489	18,077	44,[illegible]	29,711
February	43,366	19,806	45,754	29,805
March	48,397	17,394	—	—
April	—	—	—	—
May	46,423	46,280	—	—
June	49,995	31,386	—	—
July	46,512	32,734	—	—
August	38,727	29,178	—	—
September	56,760	33,837	—	—
October	48,528	32,314	—	—
November	47,916	31,092	—	—
December	47,452	31,175	—	—

WESTRALIAN GOLD PRODUCTION

	1958	1959	1960
	Oz.	Oz.	Oz.
January	66,562	63,924	64,794
February	65,965	65,035	66,789
March	65,420	65,408	61,941
April	60,855	62,686	65,373
May	64,196	64,184	—
June	67,929	74,590	—
July	81,106	78,974	—
August	68,610	—	—
September	68,744	—	—
October	70,128	70,427	—
November	67,562	68,858	—
December	120,106	117,474	—
Total	867,187	861,122	—

AUSTRALIAN GOLD OUTPUTS

	4-Week Period			
	To April 26		To May 24	
	Tons	Oz.	Tons	Oz.
Central Norseman	14,118	6,852	14,169	7,006
Gold Mines of Kalgoorlie	41,508	11,347	41,156	10,753
Gt. Boulder Gold Mines*	—	—	—	—
Gt. Western Consolidated	30,312	4,504	31,641	4,641
Lake View and Star*	—	—	—	—
North Kalgurli	42,608	8,811	—	—
Sons of Gwalia	12,188	2,094	11,414	2,859
Mount Morgan	—	5,238	—	—

* 3 Months.

ONTARIO GOLD AND SILVER OUTPUT

	Tons Milled	Gold Oz.	Silver Oz.	Value Canad'n $
December, 1958	787,573	219,351	30,989	7,490,094
January, 1959	799,178	227,656	41,277	7,700,672
February	727,843	227,981	32,976	7,798,523
March	807,952	223,728	33,045	7,616,425
April	776,583	225,027	32,778	7,712,425
May	791,199	227,924	34,006	7,713,970
June	768,725	213,486	31,692	7,178,823
July	774,749	221,814	32,172	7,498,030
August	683,819	191,598	29,141	6,428,545
September	754,208	213,772	34,139	7,116,556
October	794,030	227,192	34,733	7,558,567
November	770,437	227,176	35,262	7,600,949
December	775,803	221,377	40,807	7,388,654
January, 1960	778,103	226,856	27,617	7,550,068
February	755,569	222,484	35,003	7,446,848
March	804,309	229,457	37,202	7,646,044

MISCELLANEOUS GOLD AND SILVER OUTPUTS

	April		May	
	Tons	Oz.	Tons	Oz.
Clutha River	—	306	—	451
Lampa (Peru)†	—	33,043	—	—
New Guinea Goldfields	4,073	1,068	—	—
Yukon Consol.	—	—	—	—

† Oz. Silver : Copper, 83 tons ; 92.

AUSTRALIAN BASE-METAL OUTPUTS

Period	Concentrate Production (Long Tons)		
	Zinc	Copper (*a*)	Lead
1959	246,693	89,162	305,163
Provisional 1959—January	12,946	7,744	14,874
February	23,658	8,493	26,361
March	27,377	9,776	30,402
April	—	—	—
May	—	—	—
June	—	—	—
July	—	—	—
August	—	—	—
September	—	—	—
October	—	—	—
November	—	—	—
December	—	—	—

(*a*) includes Cu content of direct smelting ore.

OUTPUTS OF MALAYAN TIN COMPANIES IN LONG TONS OF CONCENTRATES

	Mar.	April	May
Ampat Tin	68	58½	68½
Austral Amalgamated	—	—	—
Ayer Hitam	622*	—	—
Batu Selangor	—	—	—
Berjuntai	216	170	151
Chenderiang	46½*	—	—
Gopeng Consolidated	334½*	—	—
Hongkong Tin	74*	—	—
Idris Hydraulic	53*	—	—
Ipoh	114*	—	—
Jelapang Tin	—	—	—
Kampong Lanjut	95½	81½	89
Kamunting	170	139	142
Kent (F.M.S.)	56½*	—	—
Kepong	—	—	—
Killinghall	102*	—	—
Kinta Kellas	28	29	29
Kinta Tin Mines	—	—	—
Klang River	—	—	—
Kramat	74	63	63
Kuala Kampar	76	91	115
Kuala Lumpur	—	—	—
Kuchai	—	—	—
Lahat Mines	—	—	—
Larut	—	—	—
Lower Perak	162	167½	105
Malayan	923*	—	—
Malaysiam	5	—	—
Pacific Tin Consolidated	—	—	—
Pahang Consolidated	594*	—	—
Pengkalen	105½*	—	—
Petaling Tin	334*	—	—
Puket	—	—	—
Rahman Hydraulic	—	—	—
Rambutan	33*	—	—
Rantau	43	42½	53½
Rawang Concessions	—	—	—
Rawang Tin Fields	—	—	—
Renong	—	—	—
Selayang	44*	—	—
Siamese Tin Syndicate (Malaya)	20	33	—
Southern Kinta	280	271	344
Southern Malayan	765*	—	—
Southern Tronoh	—	—	—
Sungei Besi	244½*	—	—
Sungei Kinta	272*	—	—
Sungei Way	321½*	—	—
Taiping Consolidated	—	—	—
Tambah	—	—	—
Tanjong	216*	—	—
Tekka	17*	—	—
Tekka-Taiping	—	—	—
Temoh	14*	—	—
Tongkah Compound	—	—	—
Tongkah Harbour	103	108½	148½
Tronoh	680½*	—	—
Ulu Klang	—	—	—

* 3 Months.

MISCELLANEOUS TIN COMPANIES' OUTPUTS IN LONG TONS OF CONCENTRATES

	April		May	
	Tin	Columbite	Tin	Columbite
Amalgamated Tin Mines	347	47	—	327
Anglo-Burma Tin*	19	—	—	—
Bangrin	85	—	—	—
Beralt	7	159†	6	160†
Bisichi	42	35	—	—
Ex-Lands Nigeria	42	—	42	—
Geevor	52	—	—	—
Gold and Base Metal	71	11	—	—
Jantar Nigeria	17	17	—	—
Jos Tin	10½	—	—	—
Kaduna Prospectors	5	—	4	—
Kaduna Syndicate	26½	—	16½	—
Katu Tin	24	—	—	—
Kelfi Tin	—	—	—	—
London Nigerian Mines	—	—	—	—
Mawchi Mines	—	—	—	—
Naraguta Extended	—	—	—	—
Naraguta Karama	8	—	—	—
Naraguta Tin	—	—	—	—
Renong Consolidated	—	—	—	—
Ribon Valley (Nigeria)	—	—	—	—
Siamese Tin Syndicate	119	—	—	—
South Bukeru	—	—	—	—
South Crofty	66	—	71	—
Tavoy Tin	—	—	—	—
Tin Fields of Nigeria	—	—	—	—
United Tin Areas of Nigeria	24	1	—	—

* 3 Months. † Wolfram.

SOUTH AFRICAN MINERAL OUTPUT

February, 1960.

Gold	1,714,112 oz.
Silver	170,057 oz.
Diamonds	59,128 carats.*
Coal	3,278,340 tons.
Copper	(*a*) — tons in matte and copper-gold concentrates. (*b*) 3,031 tons of 99·54%.
Tin	241 tons concs.
Platinum (concentrates, etc.)	—
Platinum (crude)	—
Asbestos	13,640 tons.
Chrome Ore	73,307 tons.
Manganese Ore	95,952 tons.
Lead Concs.	— tons.

* *January, 1960.*

IMPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM

		Mar.	April
Iron Ore	tons	1,398,768	1,304,037
Manganese Ore	,,	30,634	115,194
Iron and Steel	,,	105,686	123,013
Iron Pyrites	,,	2,887	29,950
Copper Metal	,,	43,917	43,110
Tin Ore	,,	4,786	3,135
Tin Metal	,,	10	158
Lead	,,	16,125	22,979
Zinc Ore and Conc.	,,	26,848	20,356
Zinc	,,	19,801	15,094
Tungsten Ores	,,	576	761
Chrome Ore	,,	21,749	18,928
Bauxite	,,	28,458	54,829
Antimony Ore and Concs.	,,	1,208	1,219
Titanium Ore	,,	32,416	26,042
Nickel Ore	,,	—	—
Tantalite/Columbite	,,	100	19
Sulphur	,,	45,723	49,619
Barytes	,,	5,880	2,123
Asbestos	,,	9,276	11,420
Magnesite	,,	6,332	10,105
Mica	,,	351	594
Graphite	,,	911	423
Mineral Phosphates	,,	122,426	123,622
Molybdenum Ore	,,	690	747
Nickel	cwt.	61,716	64,054
Aluminium	,,	644,556	549,516
Mercury	lb.	107,112	188,383
Bismuth	,,	55,250	21,621
Cadmium	,,	302,753	142,955
Cobalt and Cobalt Alloys	,,	139,031	354,739
Selenium	,,	27,374	29,657
Petroleum Motor Spirit	1,000 gals.	97,194	70,581
Crude	,,	910,108	953,257

Prices of Chemicals

The figures given below represent the latest available.

		£	s.	d.
Acetic Acid, Glacial	per ton	106	0	0
,, ,, 80% Technical	,,	97	0	0
Alum, Comml.	,,	25	0	0
Aluminium Sulphate	,,	16	10	0
Ammonia, Anhydrous	per lb.		2	0
Ammonium Carbonate	per ton	59	0	0
,, Chloride, 98%	,,	28	12	6
,, Phosphate (Mono- and Di-)	,,	102	0	0
Antimony Sulphide, golden	per lb.		2	9
Arsenic, White, 99/100%	per ton	47	0	0
Barium Carbonate 98–99%	,,	42	0	0
,, Chloride	,,	45	0	0
Barytes (Bleached)	,,	20	0	0
Benzene	per gal.		5	2
Bleaching Powder, 35% Cl.	per ton	30	7	6
Borax	,,	46	0	0
Boric Acid, Comml.	,,	77	0	0
Calcium Carbide	,,	40	17	9
,, Chloride, solid, 70/75%	,,	13	5	0
Carbolig Acid, crystals	per lb.		1	6
Carbon Bisulphide	per ton	62	10	0
Chromic Acid (ton lots)	per lb.		2	2½
Citric Acid	per cwt.	9	15	0
Copper Sulphate	per ton	80	0	0
Creosote Oil (f.o.r. in Bulk)	per gal.		1	2
Cresylic Acid, refined	,,		7	0
Hydrochloric Acid 28° Tw.	per carboy		11	6
Hydrofluoric Acid, 59/60%	per lb.		1	1
Iron Sulphate	per ton	3	5	0
Lead, Carbonate, white	,,	122	0	0
,, Nitrate	,,	110	0	0
,, Oxide, Litharge	,,	112	15	0
,, Red	,,	110	15	0
Lime Acetate, brown	,,	40	0	0
Lithopone	,,	57	10	0
Magnesite, Calcined	,,	20	0	0
,, Raw	,,	13	0	0
Magnesium Chloride, ex Wharf	,,	16	0	0
,, Sulphate, Comml.	,,	15	10	0
Methylated Spirit, Industrial, 66 O.P.	per gal.		6	1
Nickel Sulphate	per ton	180	0	0
Nitric Acid, 80° Tw.	,,	32	0	0
Oxalic Acid	,,	132	0	0
Phosphoric Acid (S.G. 1·750)	per lb.		1	4
Potassium Bichromate	,,		½	2½
,, Bromide	,,	11	2	6
,, Carbonate (hydrated)	per ton	74	10	0
,, Chloride	,,	21	0	0
,, Iodide	per kilo		15	3
,, Amyl Xanthate	,,	Nominal		
,, Hydrate (Caustic) flake	per ton	92	0	0
,, Nitrate	per cwt.	4	1	0
,, Permanganate	per ton	198	0	0
,, Sulphate, 50%	,,	20	13	0
Sal-Ammoniac	,,	70	0	0
Sodium Acetate	,,	63	0	0
,, Arsenate, 58–60%	,,	Nominal		
,, Bicarbonate	,,	18	10	0
,, Bichromate	per lb.		1	0
,, Carbonate (Soda Ash) 58%	,,	16	0	0
,, Chlorate	,,	77	0	0
,, Cyanide	per cwt.	6	18	10
,, Hydrate, 76/77%, solid	per ton	33	0	0
,, Hyposulphite, Comml.	,,	35	0	0
,, Nitrate, Comml.	,,	29	0	0
,, Phosphate (Dibasic)	,,	40	10	0
,, Prussiate	per lb.		1	0½
,, Silicate	per ton	11	10	0
,, Sulphate (Glauber's Salt)	,,	9	15	0
,, ,, (Salt-Cake)	,,	10	0	0
,, Sulphide, flakes, 60/62%	,,	38	12	6
,, Sulphite, Comml.	,,	27	15	0
Sulphur, American, Rock (Truckload)	,,	13	0	0
,, Ground, Crude	,,	17	10	0
Sulphuric Acid, 168° Tw.	,,	12	0	0
,, ,, free from Arsenic, 140° Tw.	,,	8	10	0
Superphosphate of Lime, 18% P_2O_5	,,	14	18	6
Tin Oxide	,,	Nominal		
Titanium Oxide, Rutile	,,	172	0	0
,, White, 25%	,,	85	0	0
Zinc Chloride	,,	95	0	0
,, Dust, 95/97% (4-ton lots)	,,	131	0	0
,, Oxide	,,	100	0	0
,, Sulphate	,,	32	0	0

Share Quotations

Shares of £1 par value except where otherwise stated.

GOLD AND SILVER:	May 10, 1960 £ s. d.	June 8, 1960 £ s. d.
SOUTH AFRICA:		
Blinkpoort (5s.)	2 18 9	2 17 6
Blyvooruitzicht (2s. 6d.)	1 4 6	1 4 9
Bracken (10s.)	1 3 6	1 3 9
Brakpan (3d.)	4 3	4 3
Buffelsfontein (10s.)	1 17 6	1 19 9
City Deep	14 6	14 0
Consolidated Main Reef	14 3	14 3
Crown Mines (10s.)	1 1 6	1 1 9
Daggafontein (5s.)	1 0 3	19 3
Dominion Reefs (5s.)	11 8	11 6
Doornfontein (10s.)	1 9 3	1 8 3
Durban Roodepoort Deep (10s.)	1 6 6	1 5 0
East Champ d'Or (2s. 6d.)	1 9	1 9
East Daggafontein (10s.)	8 3	8 3
East Geduld (4s.)	18 0	16 6
East Rand Ext. (5s.)	1 0 0	1 0 0
East Rand Proprietary (10s.)	1 10 6	1 6 0
Freddies Consol.	1 9	1 6
Free State Dev. (5s.)	4 9	4 6
Free State Geduld (5s.)	5 17 6	5 16 3
Free State Saaiplaas (10s.)	12 9	12 6
Geduld	2 10 6	2 13 0
Government Gold Mining Areas (3d.)	2 3	2 3
Grootvlei (5s.)	18 9	18 0
Harmony (5s.)	1 8 3	1 7 3
Hartebeestfontein (10s.)	2 8 6	2 9 6
Libanon (10s.)	12 3	12 6
Loraine (10s.)	1 5 6	1 6 3
Luipaards Vlei (2s.)	7 6	7 9
Marievale (10s.)	1 4 3	1 4 3
Modderfontein B (3d.)	1 9	1 9
Modderfontein East	12 3	12 0
New Kleinfontein	3 9	3 9
New Pioneer (5s.)	1 9 3	1 12 0
New State Areas (15s. 6d.)	9	1 0
President Brand (5s.)	2 15 0	2 16 3
President Steyn (5s.)	1 1 9	1 1 3
Rand Leases (9s. 3d.)	6 0	6 0
Randfontein	16 6	16 6
Rietfontein (3s.)	3 6	3 6
Robinson Deep (5s. 6d.)	5 0	4 6
Rose Deep (3s. 6d.)	10 0	10 0
St. Helena (10s.)	3 3 6	3 5 6
Simmer and Jack (1s. 6d.)	1 3	1 3
South African Land (3s. 6d.)	13 0	12 3
Springs (5d.)	1 3	1 3
Stilfontein (5s.)	1 11 0	1 11 6
Sub Nigel (3d.)	9 9	9 3
Vaal Reefs (5s.)	2 1 9	2 2 3
Van Dyk (3d.)	3 3	3 6
Venterspost (10s.)	18 0	19 6
Virginia (5s.)	3 9	3 6
Vlakfontein (10s.)	17 0	15 6
Vogelstruisbult (3d.)	5 9	5 6
Welkom (5s.)	14 3	13 9
West Driefontein (10s.)	8 2 6	4 0 0
West Rand Consolidated (10s.)	18 3	17 3
West Witwatersrand Areas (2s. 6d.)	2 15 6	2 15 0
Western Holdings (5s.)	5 17 6	5 15 0
Western Reefs (5s.)	1 6 3	1 6 3
Winkelhaak (10s.)	1 0 0	19 9
Witwatersrand Nigel (2s. 6d.)	1 0	1 0
Zandpan (10s.)	15 0	14 6
RHODESIA:		
Cam and Motor (2s. 6d.)	—	—
Chicago-Gaika (10s.)	17 6	16 3
Coronation (2s. 6d.)	5 0	5 3
Falcon (5s.)	9 6	9 0
Globe and Phœnix (5s.)	1 11 3	1 11 3
Motapa (5s.)	—	—
GOLD COAST:		
Amalgamated Banket (3s.)	1 0	9
Ariston Gold (3s. 6d.)	4 0	4 0
Ashanti Goldfields (4s.)	19 9	1 0 0
Bibiani (4s.)	2 9	2 9
Bremang Gold Dredging (5s.)	2 9	3 6
Ghana Main Reef (5s.)	2 9	3 0
Konongo (2s.)	1 6	1 6
Kwahu (2s.)	6 0	5 9
Offin River (2s. 6d.)	3 6	3 6
Western Selection (5s.)	5 3	4 9
AUSTRALASIA:		
Gold Fields Aust. Dev. (3s.), W.A.	1 6	1 6
Gold Mines of Kalgoorlie (10s.)	7 3	7 3
Great Boulder Propriet'y (2s.), W.A.	11 3	11 3
Lake View and Star (4s.), W.A.	1 6 6	1 6 3
Mount Morgan (10s.), Q.	16 0	15 9
New Guinea Gold (4s. 3d.)	2 0	2 0
North Kalgurli (1912) (2s.), W.A.	10 0	9 6
Sons of Gwalia (10s.), W.A.	2 6	2 6
Western Mining (5s.), W.A.	9 6	9 6

	May 10, 1960 £ s. d.	June 8, 1960 £ s. d.
MISCELLANEOUS:		
Fresnillo ($1·00)	1 6 6	1 7 0
Kentan Gold Areas	1 6 9	1 6 9
St. John d'el Rey, Brazil	6 5 0	6 0 0
Yukon Consolidated ($1)	4 9	4 6
COPPER:		
Bancroft Mines (5s.), N. Rhodesia	17 6	18 6
Esperanza (2s. 6d.), Cyprus	2 3	2 0
Indian (2s.)	5 3	5 6
MTD (Mangula) (5s.)	9 6	9 0
Messina (5s.), Transvaal	5 4 6	1 1
Mount Lyell (5s.), Tasmania	5 6	5 3
Nchanga Consolidated, N. Rhodesia	2 15 0	2 16 0
Rhokana Corporation, N. Rhodesia	2 9 3	2 9 6
Roan Antelope (5s.), N. Rhodesia	6 6	6 6
Tanganyika Concessions (10s.)	1 10 0	1 10 6
LEAD-ZINC:		
Broken Hill South (1s.), N.S.W.	12 6	12 9
Burma Mines (3s. 6d.)	1 9	1 6
Consol. Zinc Corp. Ord.	3 13 0	3 17 0
Lake George (5s.), N.S.W.	3 9	3 3
Mount Isa, Queensland (5s. Aust.)	2 9 6	2 16 0
New Broken Hill (5s.), N.S.W.	2 4 0	2 10 6
North Broken Hill (5s.), N.S.W.	6 0 0	1 3 0
Rhodesia Broken Hill (5s.)	9 3	9 6
San Francisco (10s.), Mexico	19 0	19 3
TIN:		
Amalgamated Tin (5s.), Nigeria	9 6	10 0
Ampat (4s.), Malaya	14 6	13 0
Ayer Hitam (5s.), Malaya	4 5 0	5 6 3
Beralt (5s.), Portugal	1 9 0	1 12 0
Bisichi (2s. 6d.), Nigeria	5 9	6 0
Ex-Lands (2s.), Nigeria	3 3	3 3
Geevor (5s.), Cornwall	1 4 3	1 4 0
Gold Base Metals (2s. 6d.), Nigeria	1 9	2 0
Hongkong (5s.), Malaya	6 6	9 9
Jantar Nigeria (3s.)	4 6	6 0
Kaduna Syndicate (2s.), Nigeria	2 6	2 7½
Kamunting (5s.), Malaya	16 9	18 9
Malayan Tin Dredging (5s.)	1 4 9	1 6 6
Mawchi Mines (4s.), Burma	1 3	1 3
Naraguta Extended (5s.), Nigeria	1 6	1 6
Pahang (5s.), Malaya	9 9	10 9
Siamese Synd. (5s.)	13 0	16 9
South Crofty (5s.), Cornwall	4 6	4 7½
Southern Kinta (5s.), Malaya	1 9 3	1 8 9
Southern Malayan (5s.)	18 6	1 0 9
Southern Tronoh (5s.), Malaya	13 6	16 3
Sungei Besi (4s.), Malaya	1 4 0	1 14 0
Sungei Kinta, Malaya	16 6	16 6
Tekka (12s. 6d.), Malaya	9 9	9 6
Tronoh (5s.), Malaya	1 14 9	1 19 9
United Tin Areas (2s. 6d.), Nigeria	—	2 6
DIAMONDS:		
Anglo American Investment	11 15 0	12 15 0
Consol African Selection Trust (5s.)	1 3 0	1 2 0
Consolidated of S.W.A. Pref. (10s.)	10 3	10 3
De Beers Deferred (5s.)	6 13 9	7 6 3
FINANCE, ETC.		
African & European (10s.)	3 7 6	3 5 0
Anglo American Corporation (10s.)	7 10 0	7 10 0
Anglo Transvaal 'A' (5s.)	1 18 9	2 1 3
British South Africa (15s.)	3 19 6	3 19 0
British Tin Investment (10s.)	1 7 6	1 10 9
Broken Hill Proprietary	3 7 6	3 10 0
Camp Bird (10s.)	8 9	8 9
Central Mining	3 7 0	3 9 3
Central Provinces Manganese (10s.)	1 12 9	1 11 9
Consolidated Gold Fields	3 1 6	3 0 3
Consolidated Mines Selection (10s.)	1 10 0	1 9 6
Corner House	14 3	14 9
East Rand Consolidated (5s.)	2 0	2 3
Free State Development (5s.)	4 9	4 6
General Exploration O.F.S. (2s. 6d.)	3 9	4 0
General Mining and Finance	4 15 0	4 12 6
Hendersons (4s.)	9 9	9 6
Johannesburg Consolidated	2 10 0	2 10 3
London & Rhod. M. & L. (5s.)	6 0	5 6
London Tin Corporation (4s.)	11 3	12 6
Lydenburg Est. (5s.)	13 6	14 0
Marsman Investments (10s.)	1 9	2 0
National Mining	2 3	2 3
Rand Mines (5s.)	3 7 6	3 12 6
Rand Selection (5s.)	2 7 0	2 8 3
Rhodesian Anglo American (10s.)	3 4 3	3 5 6
Rhodesian Corporation (5s.)	3 0	3 0
Rhodesian Selection Trust (5s.)	11 6	11 9
Rio Tinto (10s.)	1 13 0	1 15 0
Selection Trust (10s.)	4 8 9	4 12 6
South West Africa Co. (3s. 4d.)	16 0	16 0
Union Corporation (2s. 6d.)	2 10 0	2 10 6
Vereeniging	4 17 6	5 2 6
West Rand Inv. Trust (10s.)	2 8 9	2 10 0

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section abstracts of important articles and papers appearing in technical journals and proceedings of societies are given together with brief records of other articles and papers; also notices of new books and pamphlets and lists of patents on mining and metallurgical subjects.

Diamond Recovery at Alexander Bay

The *Journal* of the South African Institute of Mining and Metallurgy for April contains a paper by D. B. Smit, N. Orsmond, and J. E. de L. Strydom describing the "Diamond Recovery Plant, State Alluvial Diggings, Alexander Bay." Diamonds were discovered in this part of the Namaqualand coast in 1925 and in 1928 the area was proclaimed a State digging. The controlled output was until 1956 processed through a jig plant, but it was then discovered from tests carried out on the tailings that if the gravels were reprocessed in a heavy-media separation plant sufficient diamonds would be recovered to pay for the erection of the plant and still show a profit. The tests also proved that the old recovery plant was only about 83% efficient and that most of the diamonds not recovered were the off-colour and the smaller ones—*i.e.* below two carats. The average size of diamonds becomes smaller as one moves south from the Orange River and as most of the future mining would have to be done in this area it was apparent that a more efficient means of recovery was essential if undue diamond losses were to be avoided. It was finally decided to erect a heavy-media separation plant and work was put in hand for the erection of such a plant with a capacity of 70 tons of gravel per hour.

Tests carried out in a pilot plant in 1955 showed that if scrubbing was applied the volume of gravel from the screening plants could be reduced by almost 50%, thus enabling the H.M.S. plant to cope with the required increased tonnage. No recovery section was originally contemplated because it was thought at the time that the concentrates from the heavy-media separation cone could be hand-sorted. However, the higher production target would necessitate the hand-sorting of approximately 48 tons of concentrates daily and, as this was well-nigh impossible, assistance was sought from the Diamond Research Laboratory, Johannesburg, who carried out various experiments on concentrates and concluded "that the modified grease and electrostatic process can be applied to recover the diamonds from heavy-media separation concentrates at the State alluvial diggings. All gravel larger than 4 mm. can be treated by the grease-belt process and smaller sizes by electrostatic separation." During these tests it was also proved that most of the small stones, which normally slipped by during hand-sorting, could be recovered. It was therefore finally decided after consideration of the various factors to erect a complete treatment plant on the lines which tests had indicated to be the most suitable for conditions at Alexander Bay. The plant was completed and commissioned during August, 1957.

The complete plant consists of three major sections—namely, storage and scrubbing section, heavy-media separation section, and diamond recovery section. Screening plants for the removal of sand and barren boulders from the mined gravels are situated in the mining areas and do not form part of the recovery plant.

The *plus* $\frac{5}{64}$ in. *minus* 1 in. gravel from the screening plants is tipped into a 6,000-ton storage bin from where it is constantly fed into two 7 ft. by 16 ft. Fraser and Chalmers scrubbers at the rate of about 112 tons per hour, the total operation time being 24 hours per day in a five-day week. Boulders 4 in. to 6 in. diameter recovered from the mining area are used as a grinding medium and by the addition of sea-water the operating viscosity is maintained at about 52% solids. The scrubbers discharge on to two 5 ft. by 14 ft. double-deck F-type Symons vibrating screens equipped with sea-water sprays having a flow-rate of about 300 gal. per min. The *minus* $\frac{5}{64}$ in. product washed out on the screens has a specific gravity of 1·18 and is pumped to sea at the rate of about 700 g.p.m. by means of two 10 in. by 8 in. Denver D.R.L. pumps (one stand-by).

The remaining 60 tons per hour scrubbed gravel is then conveyed to the 400-ton surge bin which is part of the heavy-media separation section. This section consists of the 400-ton surge bin, H.M.S. cone, and the recrush section. At the 400-ton surge bin the gravel from the scrubbing section is again washed on two 5 ft. by 12 ft. double-deck F-type Symons screens equipped with fresh-water sprays in order to remove the chlorides and any remaining *minus* $\frac{5}{64}$ in. product, average spray-flow being about 220 g.p.m. The *minus* $\frac{5}{64}$ in. product which has a s.g. of 1·03 is pumped to sea at the rate of about 300 g.p.m. by means of two 5 in. by 5 in. Denver D.R.L. pumps (one stand-by). This quantity includes the *minus* 10 mesh tailings from the H.M.S. cleaning circuit.

Approximately 66 tons per hour of clean gravel, including the recirculation gravel from the recrush section, is then taken over a continuous weigher to the 9-ft. diameter H.M.S. cone which has a maximum capacity of 70 tons per hour. All tramp iron is removed before the gravel enters the cone. The cone is operated at a s.g. of 2·9, with the s.g. differential between the cone overflow and underflow media being maintained at about 0·02 to 0·04; 65D ferrosilicon is used as the medium and

the cone density is controlled by means of a 36-in. Wemco dewatering-type densifier.

The float product from the cone flows on to two 4 ft. by 10 ft. double-deck Allis-Chalmers low-head vibrating screens, arranged in series, where all ferrosilicon is washed from the gravel by means of fresh-water sprays fitted to the washing screen only, the spray-flow being about 250 g.p.m. The *plus* 10 mesh *minus* $\frac{3}{4}$ in. product being tailings is dumped into the sea and the *plus* $\frac{3}{4}$ in. product is taken to the re-crush section where it is crushed to *minus* $\frac{3}{4}$ in. in a 3-ft. Symons cone-crusher and then conveyed back to the 400-ton surge bin for recirculation. The sink product from the cone is similarly washed on two 2 ft. by 10 ft. single-deck Allis-Chalmers low-head vibrating screens to remove all ferrosilicon, spray-flow being about 50 g.p.m.

The clean *plus* 10 mesh H.M.S. concentrate which has been reduced to between 2 tons and 2·5 tons per hour is then conveyed to two 60-ton storage bins in the recovery section for final treatment. Part of the *minus* 10 mesh product from both sink-and-float drain screens is pumped back into cone circulation, the float medium return pump being a 4-in. rubber-lined K-type Wilfley and the sink medium return pump being a 4-in. rubber-lined Vacseal. The remaining *minus* 10 mesh product from the drain screens is diverted to the sink-and-float *minus* 10 mesh washing screen product which flows through a magnetizing block into a 20 ft. diameter Dorr thickener. The solids are flocculated and pumped over two 24 in. Wemco magnetic separators arranged in series where the ferrosilicon is reclaimed and the tailings gravitated to a sump and pumped to the 400-ton surge bin for disposal. A settling dam of 1,200 cu. ft. capacity which is cleaned out once a week is used as a secondary means for ferrosilicon recovery. All pumps and pipelines handling ferro-silicon media are rubber-lined and only fresh water is used throughout the H.M.S. section, the total quantity required in the H.M.S. section being about 290 g.p.m.

In order to achieve maximum efficiency two independent processes for diamond recovery are used—namely, (*a*) electrostatic separation for treating *plus* 9 mesh *minus* $\frac{5}{32}$ in. concentrates and (*b*) grease-belt concentration for treating *plus* $\frac{5}{32}$ in. *minus* 1 in. concentrates.

Approximately 6 to 7 tons per hour of H.M.S. concentrates from the two 60-ton storage bins is fed at a costant rate into two 6 ft. diameter by 4 ft. Hardinge conical ball-mills, $1\frac{1}{2}$ in. and 2 in. diameter steel balls are used as a grinding medium, and the operating viscosity of the pulp is maintained at 80% solids by the addition of fresh water. The shell and shale carried over with the sink product are ground away and washed out of the mill discharge, together with the *minus* $\frac{5}{32}$ in. product on two 3 ft. by 8 ft. single-deck Symons F-type screens having a spray-flow of about 90 g.p.m. It is these screens that separate the concentrates into two portions—one for electrostatic separation and one for grease-belt concentration.

(*a*) *Electrostatic Separation.*—The *minus* $\frac{5}{32}$ in. product is pumped to two 3 ft. by 8 ft. Symons F-type sinkle-deck screens where the *minus* 9 mesh tailings are washed out, spray-flow being about 50 g.p.m. The tailings gravitate to a common tailings sump from where they are pumped into the sea at the rate of about 410 g.p.m. by two 5 in. by 5 in. Denver D.R.L. pumps, pulp density being 1·01.

The *plus* 9 mesh *minus* $\frac{5}{32}$ in. product is discharged into a 4-ton storage bin which allows for two days' storage. Approximately 500 lb. per hour is fed into a 30 in. diameter by 16 ft. differential grinding mill for final cleaning of the concentrates and elimination of any residue shell and shale. The pulp viscosity is maintained at 80% solids and $1\frac{1}{2}$ in. diameter steel balls are used as a grinding medium. The *minus* 9 mesh product is washed out on a 2 ft. by 5 ft. single-deck Aerovibe vibrating screen equipped with sprays having a flow of about 20 g.p.m. and is pumped to the common tailings sump *via* the 3 ft. by 8 ft. Symons screens mentioned above. The *plus* 9 mesh *minus* $\frac{5}{32}$ in. product which has been reduced to about 250 lb. per hour is accumulated in a 4-ton capacity storage bin which allows for about four days' storage.

When it is required to operate the electrostatic separator the concentrate is passed through a 1,000 lb. per hour capacity Ruggles Coles rotary drier where the moisture is removed and the temperature of the concentrate raised to above 100° C. The concentrate is then passed over a 2 ft. by 5 ft. Aerovibe double-deck dedusting screen where all dust is drawn off by means of an induction fan. Any tramp oversize gravel which may disturb the even flow of the concentrate into the separator is also removed and stored in a small bin.

Approximately 800 lb. per hour of *minus* $\frac{5}{32}$ in. concentrate is fed at a constant rate into the 4 ft. by six-stage electrostatic separator by means of vibrating feeders to ensure an even flow. Electrode potential is maintained at about 20 kV static. An average concentration ratio of about 80 to 1 is obtained. The diamonds are hand-sorted from the separator concentrates.

(*b*) *Grease-Belt Concentration.*—The *plus* $\frac{5}{32}$ in. concentrate from the Hardinge mill discharge washing screens is passed over two 3 ft. by 6 ft. single-deck Aerovibe sizing screens for classification into first, second, third grade and oversize concentrate and then accumulated in four 10-ton storage bins. As the diamonds are coated with a layer of mineral salts which would become wetted during the normal grease-belt recovery process pre-treatment with a suitable reagent or "conditioner" is necessary before the gravel is passed over the grease belts. From the 10-ton storage bins the classified concentrate is fed into eight 30 in. diameter by 66 in. rotary conditioners at a constant rate by means of vibrating feeders and natural-frequency conveyors. The concentrate is brought into contact with the reagent "Aero promotor 708" in caustic soda and is retained for about two minutes in the conditioners. The conditioned concentrate is then washed on eight 2 ft. by 5 ft. single-deck Aerovibe screens having a spray-flow of about 25 g.p.m. per screen, from where the *minus* 9 mesh product is gravitated through a trap to the common tailings sump for disposal. The classified *plus* $\frac{5}{32}$ in. concentrate is passed over eight 20 in. wide grease belts for final concentration. Flow from the water-box is approximately 35 g.p.m. to 40 g.p.m. per belt.

Depending on climatic conditions the grease used on the grease belts consists of 10% to 20% wax mixed with 90% to 80% petrolatum amber.

The diamonds are hand-sorted from the grease-belt concentrates after degreasing by boiling and the tailings dumped. The grease-belt tailings are constantly checked for diamond losses. Total fresh-water consumption in the recovery section is about 400 g.p.m.

Raising with a Mechanical Climber

A note on the use of a rise climber at Western Holdings appears in the *South African Mining and Engineering Journal* for April 22. This says that until the advent of the rise climber the practice at this mine has been for ore-passes to zig-zag upwards at angles safely above that of repose. This was necessary by virtue of the fact that the ore tends to compact if dropped vertically over any distance. Starting from the transfer level at 3,700 ft. below the collar at No. 3 shaft the 8 ft. by 6 ft. rises (one for ore and the other for waste) were advanced upwards from one level to the next. During the process of rising each pass was fully timbered to provide separate compartments for broken rock and for travelling. On holing with the next level—200 ft. above—the broken rock was drawn completely and the timber stripped for re-use in the next leg.

By this laborious process the ore-passes had reached 26 level (2,600 ft. below the collar) when the rise climber was introduced. To suit it the passes from 26 level up to 18 level were redesigned to allow a straight run from level to level at 67° above the horizontal.

From the outset, it is stated, this machine has given no trouble. The European miner and his drilling crew of three natives quickly adapted themselves to its use. A point of considerable interest is that having completed two ore-passes from 26 to 24 level there is no sign of damage to the guide rail nor has there been any mechanical failure of the air motor or driving mechanism. Rounds of 7 ft. have been broken regularly in hard quartzite using a burn round of 25 holes charged with 1¼-in. diameter cartridges of 60% Dynagel.

A study taken when the rise was 120 ft. up showed that with two jackhammers in simultaneous operation during the drilling time the complete cycle from entry to blast occupied 4 hr. 30 min. Four trips were undertaken in this cycle which are broken down as follows :—

First Trip.—Time taken to bar down and extend the guide rail and ventilation pipe : 1 hr. 9 min.

Second Trip.—Time taken to examine sockets and mark off the round : 11 min.

Third Trip.—Time taken to drill the round : 1 hr. 54 min.

Fourth Trip.—Time taken to charge up : 26 min.

Time lost between trips : 50 min.

Overall time taken for a 7-ft. round : 4 hr. 30 min.

Where speed of advance is the over-riding factor the advantages of this short cycle are obvious when compared with the original method of an alternate drilling and timbering shift.

A minor difficulty experienced in inclined rises has been the susceptibility of the trailing air hose to damage by falling rock from barring. After the hose had been damaged on two occasions a method of automatically hitching the hose to the guide rail during ascent was devised. The detaching process on the way down is also automatic and as the guide rail is on the hanging-wall side of the excavation no further damage has occurred.

Air pressures below 75 lb./sq. in. were found to be unsuitable as the climbing speed deteriorates rapidly towards zero below this figure.

The Alimak rise climber is principally speaking a movable drilling platform. It climbs in a rise at any angle with an average speed of 50 ft. a minute along a rack-equipped guide rail by means of three spring-loaded pinions which are driven by an air motor through a gearbox. The guide rail is manufactured in standard sections (6 ft. 7 in. and 3 ft. 4 in.) which, as the rising proceeds, are joined together on top of each other and secured to the hanging-wall by means of special recoverable expansion bolts. The guide has four 1¼-in. pipes included in the design for supplying the rock face with air and water.

When blasting the climber is swung back under protection of the roof at the bottom of the rise and the top of the guide rail is fitted with a nozzle-supplied header plate. The latter protects the guide rail and enables the rise to be ventilated with an effective air-water spray.

The unit includes an air-motor-driven hose reel which automatically winds up the trailing hose. There is also a valve station for operating the air and water supply from up the rise. The climber is driven from a cage hanging under the platform which holds three men. Safety features include an automatic disc brake, an independent "dead-man's handle," and climbing shoes fitting to the guide rail.

Mineral Processing at El Salvador

Mining Engineering for April carries a series of articles prepared by the staff of the Anaconda Company on its El Salvador operation in the Chilean Andes. The deposit concerned is of the porphyry copper type situated in the Atacama Province about 20 miles from Potrerillos. A summary of metallurgical operations by L. O. Fines gives a neat account of work at the property which came into production last year.

Ore from the mine's block-caving operations is reduced to *minus* 6 in. by two 30-in. gyratory crushers. After the undersize has been screened out the remaining material is further reduced to *minus* ⅝ in. by two secondary standard cone-crushers and four tertiary shorthead cone-crushers. Four 24-in. belt-conveyors, assisted by gravity flow, transport the ore directly to the feed end of the rod-mills in the concentrator's grinding units, which produce a flotation feed of 5% to 6% *plus* 65 mesh and 60% *minus* 200 mesh.

The concentrator comprises four 6,000-ton mill sections each consisting of one rod-mill and two ball-mills. The ball-mills are in closed circuit with cyclone classifiers.

Pulp from the cyclone overflow of each section passes to two rows of 28-cell machines for preliminary bulk flotation. The milk of lime modifier is added to the rod-mill ahead of flotation for proper mixing. A small amount is also added in the regrind mill to maintain the same alkalinity in roughers and cleaners. Collectors are used with pine oil as a frother and provisions are made for stage

addition of collectors and frothers to various parts of the flotation circuit. Froth from the bulk and scavenger flotation is thickened prior to regrind.

Four 9 ft. by 12 ft. regrind mills grind the thickened product to 90% *minus* 325 mesh for the cleaner-recleaner-scavenger flotation and the scavenger and rougher tails are combined to make the final tail. Final concentrate runs 45% to 50% Cu, which is conducive to production of high-grade matte for economical smelting.

The final cleaner concentrate is piped to a molybdenum concentrate thickener, where a cleaner-recleaner operation yields a floated product of molybdenum concentrate and a tailing of final cleaned copper concentrate ready for pipe-tank-rail delivery to the smelter at Potrerillos.

Flotation Circuit Data

Tons of ore treated at concentrator.	18,000
Alkalinity of feed to flotation, pH .	11·5
Consumption of burned lime per ton of ore, lb.	4 to 5
Feed to flotation :—	
Plus 65 mesh, % . . .	7 to 9
Minus 200 mesh, % . . .	60 to 65
Feed to cleaner circuit, *minus* 325 mesh, %	90 to 95
Total copper in feed, % . .	1·60 to 1·80
Total copper in final cleaner concentrate, %	48 to 55
Insoluble in final cleaner concentrate, %	5 to 7
Sulphur in final cleaner concentrate, %	25 to 30
Total copper in scavenger tailing, %	0·5 to 0·6
Total copper in rougher concentrate, %	20 to 24
Total copper in final tailing, % .	0·18 to 0·20
Leach copper in final tailing, % .	0·06 to 0·08
Tons of concentrate per day . .	600

The final tailing, which consists of dewatered bulk and scavenger tailings of 45% to 50% solids, is sent to the tailing disposal area through a lined canal. All thickener overflow water, together with concentrate thickener overflows, is returned to the concentrator head tanks for re-use in grinding and flotation circuits.

A 12·7-mile pipeline carries the final cleaned copper concentrate pulp from El Salvador to a rail-head 2·8 miles above Llanta, where it is received by two 40 ft. by 25 ft. settling tanks, each provided with a still well. Each tank has a capacity of 1,000 tons of concentrate. The slurry, after settling for a short period of time, decants at approximately 70% solids. Decanted water is removed to sump ponds through pipes at various levels on the side of the tank. The thickened pulp is discharged by spigot into railroad cars provided with splash plates to prevent spillage during transport. Each car has six bottom-discharge doors.

The loaded cars are hauled by diesel locomotive to the Potrerillos handling bin, which is divided into six separate compartments so that two cars of slurry can be discharged simultaneously ; these compartments are also necessary to minimize hang-up and packing. The concentrate cars are hosed down after discharge. The concentrate slurry is repulped by a pump before being transferred to a series of four thickeners.

Filtration of thickener discharge is accomplished on four to five 12 ft. by 14 ft. disc filters. Cake is produced at a thickness of $\frac{5}{8}$ in. to $\frac{3}{4}$ in. with moisture from 11% to 14%.

Concentrate is conveyed to wedge-type roasters, where it is further dried to 6% moisture. The dried concentrate is loaded into hopper cars and trammed to a newly-designed reverberatory furnace of 1,000-ton capacity. This magnesite and silica suspended-arch furnace produces a matte grade of 60% Cu to feed the four 12 ft. by 26 ft. converters. Copper produced by the converters is cast in 700-lb. blister cakes.

Equipment at the Potrerillos smelter has been modified and enlarged to handle an anticipated copper production of about 200,000,000 lb. a year.

Manitouwadge Mineralization

In the 66th Annual Report of the Ontario Department of Mines for 1957 a memoir on the " Geology of the Manitouwadge Area " by E. G. Pye comprises Part 8. The author says that exploration work in the Manitouwadge Lake area in 1953 and in 1954 resulted in the discovery of several ore-bodies. These are primarily base-metal deposits, the principal constituents being chalcopyrite and sphalerite. They also contain silver, which adds considerably to their value and some contain small amounts of lead, present as galena. Two occurences, one at the property of Geco Mines, Ltd., the other at the property of Willroy Mines, Ltd., are being mined profitably at the present time. Magnetite is a constituent of the iron formation and the garnet-amphibole-(biotite) schist but nowhere does it occur in bodies of sufficient grade and size as to make direct-shipping iron ore.

The mineral deposits in the Manitouwadge Lake area appear to have been formed by the replacement of pre-existing rocks. They are similar mineralogically. All contain pyrite, pyrrhotite, and quartz and usually one or more of chalcopyrite, sphalerite, galena, and silver-bearing minerals. Where the ore minerals are present they occur in variable amounts with respect to one another. It is thus possible to classify the various deposits as : (1) Copper-silver (Willroy No. 1 ore-body) ; (2) copper-zinc-silver (Geco Main and Nama Creek ore-bodies) ; (3) copper-zinc-silver-lead (Willroy No. 3 ore-body and Lun-Echo Nos. 1 and 3A deposits), and (4) zinc-silver-lead (Willroy Nos. 2 and 4 ore-bodies and the Lun-Echo, Nos. 2 and 3B deposits).

All the deposits discovered so far occur in foliated host rocks and are conformable to them, discounting the possibility of a satisfactory structural classification. The paragenetic sequence of the hypogene minerals in the deposits from evidence accumulated up to September, 1957, is as follows : Stage 1, formation of pyrite ; stage 2, introduction of quartz and pyrrhotite ; stage 3, formation of chalcopyrite, sphalerite, and cubanite, and stage 4, formation of galena, tetrahedrite, sericite, and marcasite, followed or accompanied by the formation of argentite, pyrargyrite, and native silver.

Zonal arrangements of sulphides and other minerals have been noted at the Geco mine. Here the main ore-body consists of a core of massive sulphides enclosed by an envelope of disseminated ore. The first mineral to be formed, pyrite, is disseminated throughout the host rock (muscovite-quartz schist) and also occurs in the massive sulphide core and is the most widespread. Associated with the pyrite but occurring only within or close to the ore-shoot is pyrrhotite. Chalcopyrite is more restricted and increases in abundance both inward and downward. Sphalerite, of still more limited distribution, is concentrated in the massive sulphide core and attains its maximum development in the centre of the core, below low-grade pyrite-pyrrhotite ore and above the highest-grade copper ore. Much of the galena and all of the argentite, native silver, and pyrargyrite (the last minerals to be formed) appear to be confined mainly to fractures in rock inclusions in the massive sulphides within and below the sphalerite-rich section.

In the lateral dimension, from the barren host rock inward, the successive zones are thus characterized by the appearance of the metallic minerals in the order: Pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena and silver minerals. This order coincides with the paragenetic sequence, as undoubtedly it should. The same is true of the massive sulphide core in the vertical dimension, from the top of the ore-shoot downward, except that in this case the relative positions of chalcopyrite and sphalerite are reversed.

A zonal phenomenon is also found in the Willroy No. 3 ore-body. Here no lateral zoning is apparent but a marked zonal distribution of ore minerals is evident vertically and horizontally in the direction of strike.

Several temperature indicators are present to show that the Geco and Willroy ores were formed mostly at very high temperatures and belong to the hypothermal class of Lindgren. There is little reason to doubt that the disseminated ores in the area are the result of wall-rock replacement supplemented in part by fracture filling; in too many places cubic pyrite and grains of pyrrhotite and chalcopyrite occur in wall-rock minerals, transecting but not disturbing their cleavages and crystal forms, but the massive sulphide ores—such as, those of the Geco and Willroy mines—have sharp boundaries and do not generally display relict structures of pre-existing host rocks.

Evidence indicates conclusively that the ores were formed later than the pegmatites and the rocks referred to as basic intrusives but the age of the ores relative to the diabase is not certain. At the margins of transverse diabase dykes fractures up to ¼ in. wide and extending for a few inches into the diabase have been filled with chalcopyrite. This was observed in the cores from diamond-drill holes bored as part of the exploration programme of Geco Mines, Ltd., in 1954. It is thus possible that the diabase may be pre-ore in age, but similar phenomena have been noted at the Normetal mine in Quebec and in this case Brown concluded: (1) The dyke in this case was post-ore in age and (2) the penetration effects were caused by remobilization of early chalcopyrite during the intrusion of the hot basic magma followed by redistribution along fractures formed in the cooling igneous rock. This conclusion is held at the present time to account for the occurrences at the Geco mine largely because the ores have not been found to have been influenced by the intrusion of the diabase magma. As the diabase dykes are approached the ores do not change in mineralogy, zonal arrangement of sulphides, or content of valuable metals.

A determination of the lead-isotope ratios of a sample of galena from the Geco ores by mass spectrometer indicates an age of 2,600,000,000 ± 120,000,000 years, which is close to that of leads found in the Golden Manitou and Barvue deposits in Quebec and in the gold ores in Timmins in Ontario. The lead ore from the Geco mine and other deposits is much older than the Sudbury nickel-copper ore, which is believed to have been formed in Late Precambrian time. In view of this and the tentative conclusion expressed above that the ores are pre-diabase in age it is reasonable to suppose that the ore was formed towards the close of the period of granitic intrusions and that they may be of Algoman age.

A study of the mineral deposits in the area and their association with other geological features suggests:—

(1) All the important mineral deposits discovered in the area to date have been found in, or closely associated with, muscovite-quartz schist, iron formation, or related rocks.

(2) All the important mineral deposits have been found in the uppermost part of the metasedimentary series.

(3) At the Geco mine the favourable host rock unit (the muscovite-quartz schist horizon) undergoes an abrupt decrease in width immediately west of and below the main ore-body. This decrease in thickness is thought to be the expression of a large isoclinal Z-shaped drag fold superimposed on the regional structure.

(4) The main ore-body at the Geco mine occurs east of a large right-hand deflection in the strike of the formations. This right-hand deflection in strike is thought to represent an incipient drag fold developed along the south limb of the Manitouwadge syncline. Similar structures appear to be associated with other mineral deposits in the area. Detailed mapping by E. H. M. Chown of the property of Willroy Mines, Ltd., and geological correlation based on diamond-drill hole and outcrop data indicate the possibility that the Willroy Nos. 2, 3, and 4 ore-bodies occur in iron formation, in each case east of a right-hand deflection or incipient drag fold. The Willroy No. 1 ore-body lies in muscovite-quartz schist and recent detailed surface and underground examination has revealed that in this case also the ore may lie east of an incipient drag fold. Examination of the geological map shows the Lun-Echo Gold Mines, Ltd., No. 3 deposit to lie east of a minor synclinal axis and on the basis of an electromagnetic survey and diamond drilling the same may hold true for the Nama Creek Mines, Ltd., ore-body.

(5) The massive sulphide ore at the Geco mine appears to be localized along a strike fault which has displaced bodies of microgranodiorite and pegmatite, the relative movement apparently having been down on the north side.

(6) At the Geco mine the disseminated ore west of the Fox Creek fault is interrupted by a zone of several flat dykes of microgranodiorite and pegmatite. These dykes are pre-ore in age. In general they are only sparsely mineralized; sulphides in most cases are only found close to their contacts. It is apparent that a thin flat-dipping dyke of poorly mineralized microgranodiorite or pegmatite exposed

at the surface could completely mask an important mineral deposit.

(7) The grades and distribution of the ore-bodies in the area do not bear any distinct relationships to proximity to diabase dykes or to north–south faults.

(8) The mineral deposits all pitch at flat angles in an easterly direction but not necessarily parallel to lineations. On the properties of Geco Mines and Willroy Mines the lineations have an average pitch of about 35° E. In contrast, the bottom of the massive sulphide ore at the Geco mine, west of Fox Creek, pitches 30° E.; the Willroy No. 1 ore-body, 20° to 25° E.; the Willroy No. 2 ore-body, 11° E., and the Willroy No. 3 ore-body, 45° E.

Trade Paragraphs

F. Perkins, Ltd., of Peterborough, announce the formation of a United States company named the Perkins Engine Co., Inc., with headquarters in Detroit, to market their products and provide technical and service facilities.

William H. Capper and Co., Ltd., of 8, Hertford Street, London, W. 1, have established a depot at Woolston, near Warrington, at which service facilities and a full stock of spare parts for Demag rotary compressors are available.

Oldham and Son, Ltd., of Denton, Manchester, announce that with Dunlop Rubber Australia, Ltd., they have set up a joint sales company called Dunlop Oldham Pty, Ltd., which will market the company's PG double sleeve tubular traction and other industrial batteries throughout Australia.

Locker Industries, Ltd., of Warrington, announce that as a result of a re-organization this is now the name of the company which incorporates Lockers (Engineers), Ltd., and other associate companies as well as Vimec Equipment, Ltd. The last named manufacture a vibrating feeder which was shown at the Mechanical Handling Exhibition last month and is known as the Locker Amplitrol.

Megator Pumps and Compressors, Ltd., of 43, Berkeley Square, London, announce that their American subsidiary has been appointed as sole agents in the U.S.A. for **Greengate and Irwell Rubber Co., Ltd.,** of Manchester, manufacturers of conveyor belting, and **Conflow, Ltd.,** of Nottingham, makers of spray equipment, valves, gauges, and other accessories. The Megator U.S. subsidiary, which has its headquarters at Pittsburgh, Pennsylvania, has been renamed Megator Corporation.

BTR Industries, Ltd., of Herga House, Vincent Square, London, S.W. 1, have introduced a range of fibre belts with safe working stresses ranging from 40 p.s.i. per ply up to 200 lb. p.s.i. per ply. Known as Nypac, they are nylon wefted and combined with cotton, rayon, or Terylene, according to the tensile strength required and are particularly suitable where acid or chemical contamination is likely. The belts are available in three qualities of rubber cover—4,000 lb, 3,500 lb., and 2,500 lb.

Sturtevant Engineering Co., Ltd., of Southern House, Cannon Street, London, E.C. 4, have recently published a revised catalogue of their products which is fully illustrated and covers 60 pages. This deals with fans, heating and ventilation, air conditioning, industrial process ventilation, dryers and drying systems, dust collecting systems, gas cleaning—electrostatic precipitation, pneumatic conveying, a variety of process engineering, crushing, grinding, screening, and separating, the electrostatic separator, and cathodic protection. Separate publications also recently available are devoted to the Newgate dust collector and fans for mechanical draught.

Turner Brothers Asbestos Co., Ltd., of Rochdale, have compiled a catalogue of their Poly-V drives which were the subject of an extended notice in the April issue. The booklet noticed here contains a wealth of information to guide in the selection of suitable drives with extensive tabular matter on horse-power ratings for each of the three main types. Another booklet just issued is devoted to the company's rubber conveyor belting which is well illustrated to show its applications. The range of qualities and types available are given, including those special types with synthetic fibre carcases. Notes on selection follow with tabular presentation of data. Installation details are included with particulars of belt tensioning devices and vulcanized splices.

Head, Wrightson and Co., Ltd., of Thornaby-on-Tees, announce that the name of their subsidiary company, Head Wrightson Colliery Engineering, Ltd., of Sheffield, has been changed to Head Wrightson Minerals Engineering, Ltd. The company has been known for many years as specialists in the design and supply of colliery surface equipment, but recently it has been expanding its activities into other fields, in particular in the treatment of minerals other than coal. Another important expansion will take place shortly in connexion with iron-ore treatment and it was felt that it would be an advantage if the company's name gave an indication of its widening scope. Its interest in, and capacity for, work for the coal mines at home and abroad will be maintained and there will be no change in the organization or direction.

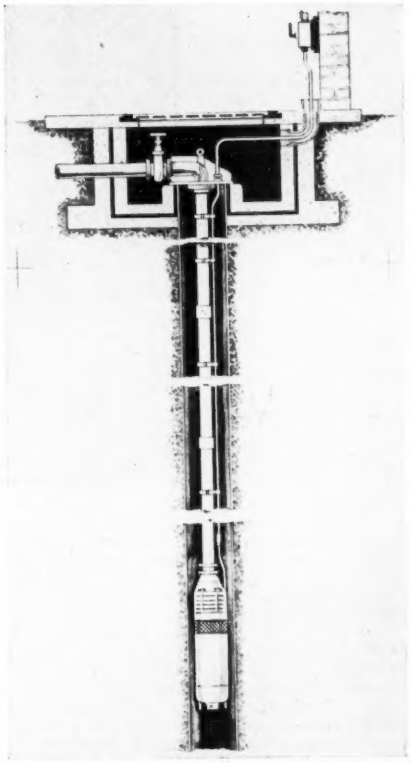
Goodyear Tyre and Rubber Co. (Great Britain), Ltd., of Wolverhampton, refer in a recent note to the manufacture of 20 tons of conveyor-belts destined for Chile. This 1,000 ft. HDNF conveyor-belt containing heavy-duty nylon fill fabric is the biggest belt of this type built in the company's works. Together with another belt of the same size (48 in. by 7 ply), it is being prepared for shipment to the order of the Nitrate Corporation of Chile, Ltd., for the Cia. Salitrera, Anglo-Lautaro's nitrate of soda producing plant at Pedro de Valdivia. The installation in the crushing section comprises part of a 1,500-ft. conveyor system driven by a 250-h.p. motor at 510 f.p.m. Caliche is the material to be handled, being crushed and screened to $1\frac{1}{2}$ in. size at 1,700 tons per hour by a group of five 7-ft. Symons cone-crushers. Each belt, weighing approximately 10 tons, is constructed in 42 oz. HDNF fabric with $\frac{5}{16}$ in. top cover, including nylon transverse breaker, and a $\frac{3}{32}$ in. bottom cover.

Johnson, Matthey and Co., Ltd., of Hatton Garden, London, E.C. 1, announce that research work carried out in collaboration with CIBA (A.R.L.), Ltd., has led to the development of two additions to their range of thermo-setting silver preparations, both being based on araldite. FSP43 is a surface-coating preparation for application by brushing and FSP49 is a conducting cement. Each is supplied in the form of two separate components which are mixed together immediately before use. The mixed components must be cured at a minimum temperature of 80° C. and will adhere to most materials that are capable of withstanding this temperature, including glasses, ceramics, graphites, and many plastics. The films, after curing, are extremely hard, have high electrical conductivities, and are resistant to water and organic solvents. Moreover the film produced by FSP43 can also be electroplated in many conventional acid baths.

Caterpillar Tractor Co., Ltd., of P.O. Box No. 162, Glasgow, have added the D4C tractor, rated at 52 drawbar horsepower, to their range. Available with either a standard or lower speed transmission, the new machine is the first in its size class to have a forward-reverse lever; the spur gear transmission has five speeds forward and four reverse. Announced simultaneously with the new D4C tractor the 955F Traxcavator is the third machine to be built by the company in Great Britain. Compared with its predecessor the 955E the 955F has many new and improved features. An increase of 25% in lugging ability is claimed for the 70 flywheel h.p. diesel engine, which has as standard the exclusive dry type air cleaner guaranteed 99·8% efficient. Reliable all-weather in-seat starting is provided by the petrol starting engine. The exclusive forward-reverse lever substantially reduces the normal gear shifting times, thus utilizing fully the speedier action which the "live" hydraulic system permits. The reservoir of the fender-mounted hydraulic control is sealed and encloses the control valves, keeping the entire system dirt-free.

Edgar Allen and Co., Ltd., of Sheffield, in their *Edgar Allen News* for April include some notes and illustrations on steel castings such as dredge top tumblers and bottom tumblers, elbows, impellers, and sleeves. In a recent announcement they refer to an order secured with their associate company, **Buell, Ltd.,** of 3, St. James's Place, London, S.W. 1, for a mineral processing plant which includes a jaw-crusher, a gyratory crusher, screens, feed tables, and a ball-mill fitted with Cromax steel grinding plate for reducing the product to 90% passing 30 B.S.S. Material from the mixing drum is fed through a pipe made from the company's heat-resisting steel (Maxhete) to a rotary kiln 170 ft. long. A rotary cooler, 55 ft. long, processes the sintered material, which is carried to the jaw granulator and gyratory crusher. Chromite and bauxite are also treated in the ball-mill, while the sintered magnesite is further crushed in a combination tube-mill. The orders received by Buell, Ltd., also include a vertical turbo dryer capable of drying china clay from filter presses, containing not more than 30% free moisture, at the rate of 4½ tons per hour of product containing not more than 10% moisture.

Pulsometer Engineering Co., Ltd., of Reading, have extended their range of electric submersible bore-hole pumps to provide capacities up to 50,000 g.p.h. for depths to 500 ft. The pump, as illustrated, is designed for bore-holes not less than 6 in. in diameter and is of the centrifugal type,



single or multi-stage according to the application. The cells of the multi-stage pumps are flanged and bolted together, the diffuser passages being cast in the cells. The bronze impellers are keyed to a steel spindle which is protected by bronze sleeves and runs in grease-lubricated bearings. Renewable bronze wearing rings are fitted on the casing where the impellers are in running contact and bronze centre bushes are provided between the cells. Provision is made to prevent sand entering the motor and the lubricant escaping into the water and a strainer plate is fitted round the suction intake between pump and motor. A non-return valve is incorporated in the pump delivery chamber. The motor which can be either single or three phase is bolted direct to the pump by a spigotted flange and is connected to it by a rigid coupling. The starter is mounted at ground level and can be of the hand or automatic pattern operated by a float gear, pressure switch, time switch, or other form of remote control.

E. Boydell and Co., Ltd., of Old Trafford, Manchester, recently demonstrated to the Press three new Muir-Hill hydraulic loaders. Known as models RD2, FD2, and FD4, the machines share a number of advanced design features including 50° roll-back bucket action combined with a pry-out force of 7,400 lb. for faster operation, bigger loads, and reduced wear and tear. The FD2 loader, which

Joy-Sullivan Drilling Barge.

has front-wheel drive, is ideal for down-hill loading and for working in loose material because of its " backing out " performance, while the FD4, which has four-wheel drive, can overcome much more adverse ground conditions and is arranged so that the drive to the rear wheels can be disconnected if required. The RD2 is a general purpose machine. Each is powered by a Fordson Power Major 3·6-litre 4-cylinder diesel engine developing 56 b.h.p. at 1,800 r.p.m. and a maximum torque of 171 lb/ft. at 1,200 r.p.m. Hydraulic power is provided by a heavy-duty gear-type pump driven through a Hardy-Spicer coupling from the engine crankshaft, high-pressure fluid passing through a double selector controlled by twin levers. A range of buckets of from ¾ to 2 cu. yd. is available fitted with abrasion-resistant blades and check plates.

Murex Welding Processes, Ltd., of Waltham Cross, Herts, held an exhibition last month at the works of Specialloid, Ltd., in Leeds. Up-to-date hand-welding electrodes, machines, and welding accessories were on view and practical demonstrations of automatic methods and manual welding given. The exhibition covered an area of some 3,000 sq. ft. and prominent among the exhibits was the " Mura-matic " machine which is being extensively used for the automatic welding of large vessels and other heavy fabrications by the submerged-arc or open-arc process. Another outstanding exhibit was the " Overlander " diesel-driven welding set designed for site work and extensively used for the welding of oil pipelines in many countries in the world, particularly in the Middle East. Motor-generator equipments and welding transformers of various capacities were also to be seen. There are more than 100 different types of Murex electrodes for the welding of all classes of metals and the very latest types were demonstrated. These include the special types for very thick plate welding, for the welding of " difficult " steels, special stainless steels, and creep resisting steels. Electrodes for the welding of aluminium, cast iron, and for hard-facing purposes were included.

Joy-Sullivan, Ltd., of 7, Harley Street, London, W. 1, in a recent announcement state that submarine drilling techniques have been advanced as a result of work carried out by their associates Joy Manufacturing Co., in the United States, on several channel deepening and widening projects including the St. Lawrence Seaway. The method involves equipping a barge with a number of Joy TM-500 drills powered by a suitable number of Joy WN-112 air-compressors, each driven by a marine-cooled diesel engine. This barge and drill " package " may be adapted for submarine blast-hole drilling to operations of various sizes in channels, canals, and rivers, and outstanding results have already been obtained. In operation the barge is anchored over the working area and becomes a self-contained drilling plant with a limited amount of mobility. Two cables are run out diagonally from each end of the barge and anchored at a distance of up to 800 ft. By winching in cable at one end of the barge while paying out at the other it can be manoeuvred in accordance with a predetermined drilling plan. Spuds, or piles, one at each corner of the barge are lowered by an air-operated hoist to ensure a stationary and level platform for drilling operations.

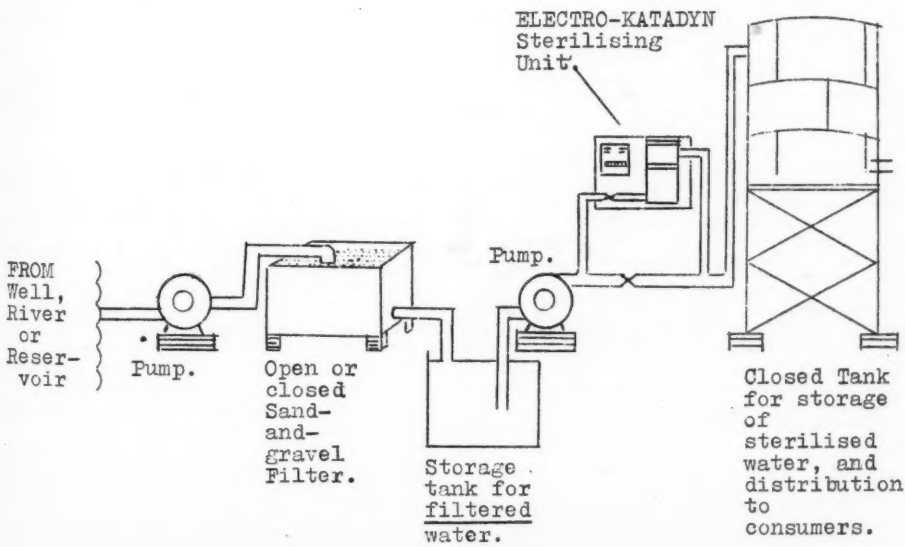
Assuming a three-drill barge is used, with drills having an effective horizontal tracking distance of 80 ft. the operation proceeds as follows :—Holes spaced on 10-ft. centres permit the sinking of nine holes from a single barge position, allotting three holes to each drill. Once a tower has been positioned for drilling it is locked in place by a quick-acting clamp and a sand pipe is lowered until it rests on the sediment or rock to be worked. The sand pipe functions as a guide for the drill steel, prevents material from caving into the drilling, and also guides the charge into the hole for firing. Drilling then proceeds in the normal manner, using air pressure to blow the holes. The drill is then raised in the tower and a dynamite loading tube lowered by air hoist down the sand pipe to the bottom of the drilling. The bottom stick of dynamite contains a detonator with a lead wire to the barge deck, so

that after the charge has been ejected from the loading tube and the tube withdrawn the leads from all holes may be connected up. The sand pipe can then be raised and the drill tower moved to the next position, where the process is repeated. When all holes have been drilled and loaded the spuds are raised and the barge is warped by the anchor winches to a position approximately 180 ft. from the blast area. After firing the barge is warped back to the next drilling position, where the entire cycle is repeated. There is little basic difference between dry and submarine drilling except that each hole must be loaded before the sand pipe is moved and each row of holes shot before the next row is drilled. The photograph shows a typical 3-drill barge installation. Note the extensions which permit forward as well as lateral movement of the drill towers for sinking two or more parallel rows without having to move the barge.

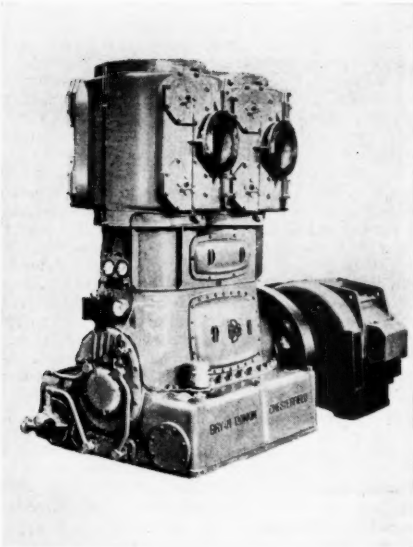
Roura and Forgas, Ltd., of 27–37, Broadwick Street, London, W. 1, draw attention to the Electro-Katadyn method of water sterilization. They suggest that the supply of safe drinking water presents an important problem in tropical and sub-tropical climates, where contaminated water may cause illness and absenteeism or lead to serious outbreaks of epidemics. The method is becoming widely used, particularly in Malaya. In most installations water is drawn from a well, river, or reservoir, and is passed through a locally-constructed sand-and-gravel filter to remove suspended matter. A predetermined proportion then passes through the Electro-Katadyn unit where it receives a measureable and strictly controlled degree of sterilization by the silver ion process. This highly sterilized concentrate is then fed back into the main flow and is calculated to sterilize the entire supply. Water so treated is suitable for storage in sealed tanks. Due to the fact that the sterile properties do not evaporate as in the case of chlorination, and the process is non-corrosive, there is no risk of re-contamination after treatment.

Where the pumps supplying the water are electrically controlled it is usual to connect the electricity supply to the unit on a common circuit. This ensures that the unit is brought into operation whenever water is being pumped. All Electro-Katadyn units are fitted with automatic flow switches, so that where pumps and unit cannot be controlled jointly the unit will commence sterilizing as soon as water flows through it, provided that the electricity supply to the unit is switched on. The unit itself occupies only 1 sq. yd. of wall-space and can be operated from the ordinary lighting circuit but can also be supplied suitably modified to operate from non-standard or d.c. supply or from car-type batteries if necessary. The only consummable items are the silver electrodes and electric current. The capacity of the electrodes is predetermined for each installation according to the activation rate required. The activation rate is based on the chemical analysis of the water to be sterilized. As an example of actual operating costs, the average for six different installations in various parts of Malaya is approximately 2¼d. per 1,000 gal. Spare sets of electrodes are available for immediate despatch from stock. The sketch shows a typical installation.

Bryan Donkin Co., Ltd., of Chesterfield, are producing a new standard range of vertical reciprocating compressors, designated Type 300/A, to replace their earlier range. Rationalization of the design and the introduction of new production methods has enabled the capital cost of the compressors to be considerably reduced while, at the



Electro-Katadyn Water Sterilization Plant.



same time, the operating efficiencies have been increased. The pressures obtainable with the compressors are as follows (p.s.i.g.) :—

Stroke	Single Stage	Two-Stage	Three-Stage
6 in.	50	250	1,200
8 in.	45	225	975
12 in.	40	200	750

The 6-in. stroke compressor can be supplied as a single, two, or three crank machine and the 8-in. and 12-in. stroke machines are made with either two or three cranks. The maximum flow of free air obtainable with the 12-in. stroke compressor at a discharge pressure of 100 p.s.i.g. is about 3,600 c.f.m. Drop-forged connecting rods are used which as well as reducing production costs also lead to a reduction of the out-of-balance forces. The big-end and main bearings are precision components with thick wall steel backs and white-metal linings and they can be fitted easily without bedding in or scraping.

The compressors are designed for continuous running and their structure is such that they can be easily dismantled and re-assembled for examination and maintenance. The crank frame doors are of light alloy and although of ample proportions to facilitate access for maintenance can be removed by one man. A centrifugal cleaner is built into the lubricating-oil system. The cylinder gland is fitted with a seep-off pipe to the low-pressure side of the compressor to prevent the escape of toxic gases to atmosphere or ingress of air during the suction stroke. The illustration shows the 12-in. two-crank unit.

Correction.—In the March issue appeared a note on a new pressure bulb type of hydrostatic tank contents gauge which was attributed to Firth Cleveland Investments, Ltd. The correct name of the company is **Firth Cleveland Instruments, Ltd.**

RECENT PATENTS PUBLISHED

☛A copy of the specification of the patents mentioned in this column can be obtained by sending 3s. 6d. to the Patent Office, Southampton Buildings, Chancery Lane, London W.C. 2, with a note of the number and year of the patent.

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18,406 of 1958 (831,930). ALUMINIUM LABORATORIES, LTD. Electrolyte for aluminium production.

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☛Publications referred to under this heading can be obtained through the Technical Bookshop of *The Mining Magazine*, 482, Salisbury House, London, E.C. 2.

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Selected Index to Current Literature

This section of the Mining Digest is intended to provide a systematic classification of a wide range of articles appearing in the contemporary technical Press, grouped under heads likely to appeal to the specialist.

* Article in the present issue of the MAGAZINE. † Article digested in the MAGAZINE.

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Production, Chile : *Copper, El Salvador.* Report on Anaconda's Newest Property—The Largest New Underground Mine in Recent Years. *Min. Engg.*, Apr., 1960.

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